US009273885B2

(12) **United States Patent**
Rodrigues et al.

(10) **Patent No.: US 9,273,885 B2**
(45) **Date of Patent: Mar. 1, 2016**

(54) **ROOF INTEGRATED PHOTOVOLTAIC SYSTEM**

(71) Applicant: **Building Materials Investment Corporation**, Dallas, TX (US)

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(73) Assignee: **Building Materials Investment Corporation**, Dallas, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/298,416**

(22) Filed: **Jun. 6, 2014**

(65) **Prior Publication Data**

US 2014/0366464 A1 Dec. 18, 2014

Related U.S. Application Data

(60) Provisional application No. 61/834,527, filed on Jun. 13, 2013, provisional application No. 61/906,593, filed on Nov. 20, 2013.

(51) **Int. Cl.**
E04D 13/18 (2014.01)
H01L 31/05 (2014.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F24J 2/5245*** (2013.01); ***F24J 2/5211*** (2013.01); ***F24J 2/5262*** (2013.01); ***H02S 20/25*** (2014.12);
(Continued)

(58) **Field of Classification Search**
CPC H01L 31/042; F24J 2/5211; F24J 2/5213; F24J 2/5215; F24J 2/465; F24J 2/4638; F24J 2/5245; F24J 2/5247; F24J 2/5252; F24J 2/5254; F24J 2/526; F24J 2/5262; H02S 20/23; H02S 20/25; H02S 40/32; H02S 40/34; H02S 40/36; Y02B 10/10; Y02B 10/12
USPC 52/173.3, 536, 539, 542, 519; 126/622, 126/623
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

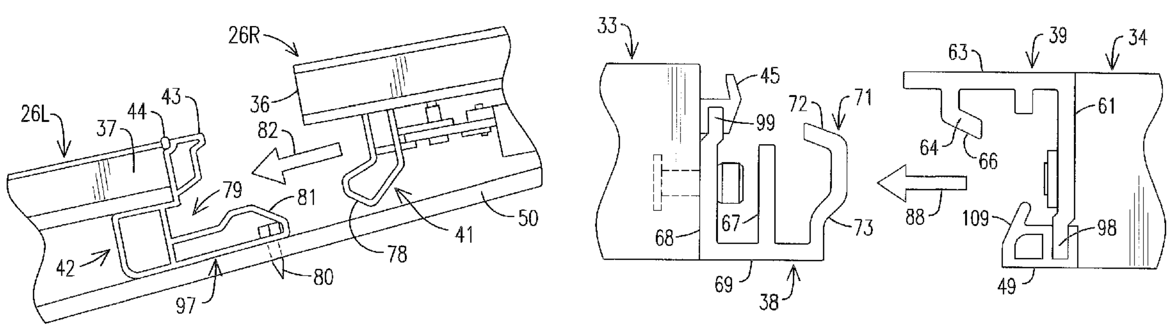
4,336,413 A 6/1982 Tourneux
4,392,009 A * 7/1983 Napoli 136/251
(Continued)

Primary Examiner — Robert Canfield
(74) *Attorney, Agent, or Firm* — Womble Carlyle Sandridge & Rice LLP

(57) **ABSTRACT**

A roof integrated photovoltaic system includes a plurality of photovoltaic panels each having a right end, a left end, a front edge, and a back edge. A right end coupler is secured to the right ends of at least some of the photovoltaic panels and a left end coupler is secured to the left ends of at least some of the photovoltaic panels. The right end couplers and the left end couplers are configured to interlock and form a seal when two of the plurality of panels are moved into end-to-end engagement with each other. At least one front edge coupler is affixed to at least some of the plurality of photovoltaic panels at the front edges thereof and at least one back edge coupler is affixed to at least some of the plurality of photovoltaic panels at the back edges thereof. The front edge couplers and the back edge couplers configured to interlock when two of the plurality of panels are moved into edge-to-edge engagement and a seal is positioned to prevent water from penetrating at the junction of a front edge of one panel and the back edge of an adjoined panel. Panels are installed on a roof in end-to-end and front edge to back edge relationship to form a photovoltaic array and are electrically interconnected to produce electricity when exposed to sunlight. Flashing and gap filling faux panels are provided as part of the system.

16 Claims, 19 Drawing Sheets



(51) **Int. Cl.**

F24J 2/52	(2006.01)
H02S 40/32	(2014.01)
H02S 20/25	(2014.01)
H02S 40/36	(2014.01)
F24J 2/00	(2014.01)

(52) **U.S. Cl.**

CPC ***H02S 40/32*** (2014.12); ***H02S 40/36*** (2014.12); *F24J 2002/0061* (2013.01); *Y02E 10/47* (2013.01); *Y02E 10/50* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,433,200	A *	2/1984	Jester et al.	136/251
4,582,953	A *	4/1986	Nagase et al.	136/259
5,409,549	A	4/1995	Mori	
5,651,837	A	7/1997	Ohtsuka et al.	
5,951,785	A *	9/1999	Uchihashi et al.	136/251
6,065,256	A	5/2000	Joko et al.	
6,093,884	A	7/2000	Toyomura et al.	
6,111,189	A *	8/2000	Garvison et al.	136/244
6,242,685	B1	6/2001	Mizukami et al.	
6,311,137	B1 *	10/2001	Kurokami et al.	702/60
6,370,828	B1	4/2002	Genschorek	
6,465,724	B1 *	10/2002	Garvison et al.	136/244
6,838,611	B2 *	1/2005	Kondo et al.	136/244
6,914,182	B2	7/2005	Takeda et al.	
6,928,775	B2	8/2005	Banister	
7,178,295	B2	2/2007	Dinwoodie	
7,297,867	B2	11/2007	Nomura et al.	
7,328,534	B2 *	2/2008	Dinwoodie	52/173.3
7,342,171	B2	3/2008	Khouri et al.	
7,413,790	B2 *	8/2008	Hutter, III	428/139
7,487,771	B1 *	2/2009	Eiffert et al.	126/622
7,713,089	B2 *	5/2010	Faust et al.	439/620.21
7,900,407	B2	3/2011	Plaisted	
7,956,279	B2 *	6/2011	Morita et al.	136/251
8,104,239	B2 *	1/2012	Fath	52/173.3
8,207,637	B2 *	6/2012	Marroquin et al.	307/147
8,382,513	B2 *	2/2013	Kobayashi	439/507
8,455,752	B2 *	6/2013	Korman et al.	136/251
8,511,006	B2 *	8/2013	Reisdorf et al.	52/173.3
8,813,460	B2 *	8/2014	Cinnamon et al.	52/747.1
8,929,094	B2 *	1/2015	Marroquin et al.	361/807
9,048,353	B2 *	6/2015	Casey et al.	
9,065,354	B2 *	6/2015	Chapman et al.	
9,076,899	B2 *	7/2015	Schrock	
2003/0154667	A1	8/2003	Dinwoodie	
2004/0000334	A1	1/2004	Ressler	
2004/0031518	A1	2/2004	Plantfeber	
2004/0187909	A1 *	9/2004	Sato et al.	136/251
2005/0241246	A1	11/2005	Sinha et al.	
2005/0257453	A1 *	11/2005	Cinnamon	52/173.3
2006/0225780	A1	10/2006	Johnson, III et al.	
2007/0181174	A1 *	8/2007	Ressler	136/251
2007/0199590	A1	8/2007	Tanaka et al.	
2007/0252716	A1 *	11/2007	Burger	340/635
2007/0295393	A1 *	12/2007	Cinnamon	136/251
2008/0190047	A1 *	8/2008	Allen	52/173.3
2008/0302030	A1 *	12/2008	Stancel et al.	52/173.3
2009/0133738	A1	5/2009	Shiao et al.	
2010/0170169	A1	7/2010	Railkar et al.	
2010/0236610	A1	9/2010	Stancel et al.	
2010/0313499	A1 *	12/2010	Gangemi	52/173.3
2010/0313501	A1 *	12/2010	Gangemi	52/173.3
2011/0154750	A1 *	6/2011	Welter et al.	52/173.3
2011/0220180	A1 *	9/2011	Cinnamon et al.	136/251
2011/0284058	A1	11/2011	Cinnamon	
2011/0314752	A1 *	12/2011	Meier	52/173.3
2012/0079781	A1	4/2012	Koller	
2013/0125482	A1 *	5/2013	Kalkanoglu et al.	52/173.3
2014/0102519	A1 *	4/2014	Rodrigues et al.	136/251
2014/0166082	A1 *	6/2014	Langmaid et al.	136/251
2014/0305050	A1 *	10/2014	Schulze et al.	52/173.3
2015/0083197	A1 *	3/2015	Langmaid et al.	136/251

* cited by examiner

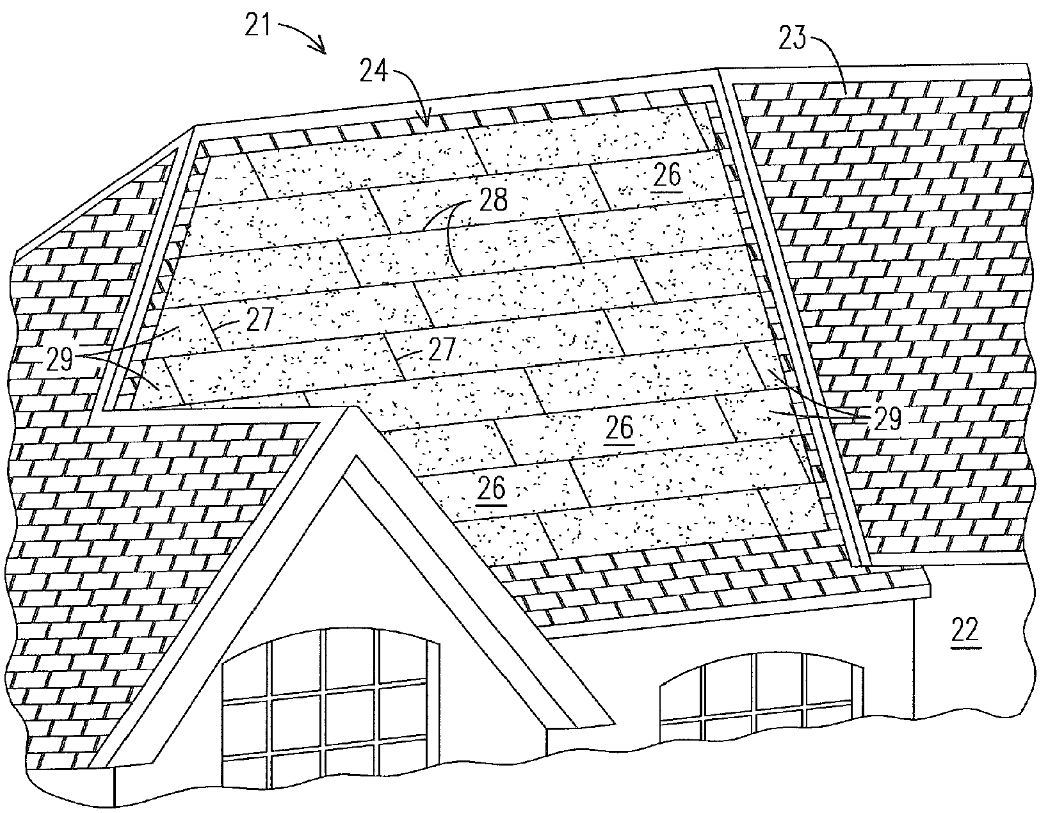


FIG. 1

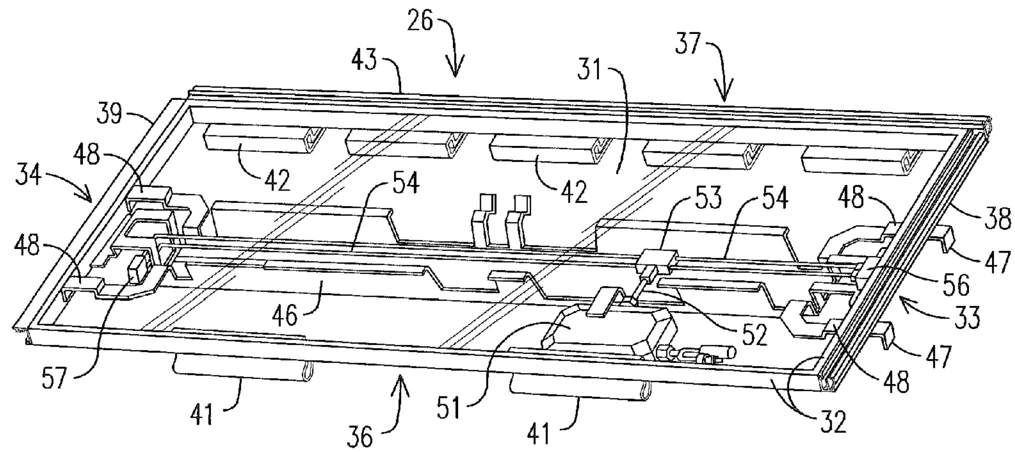


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FIG. 2

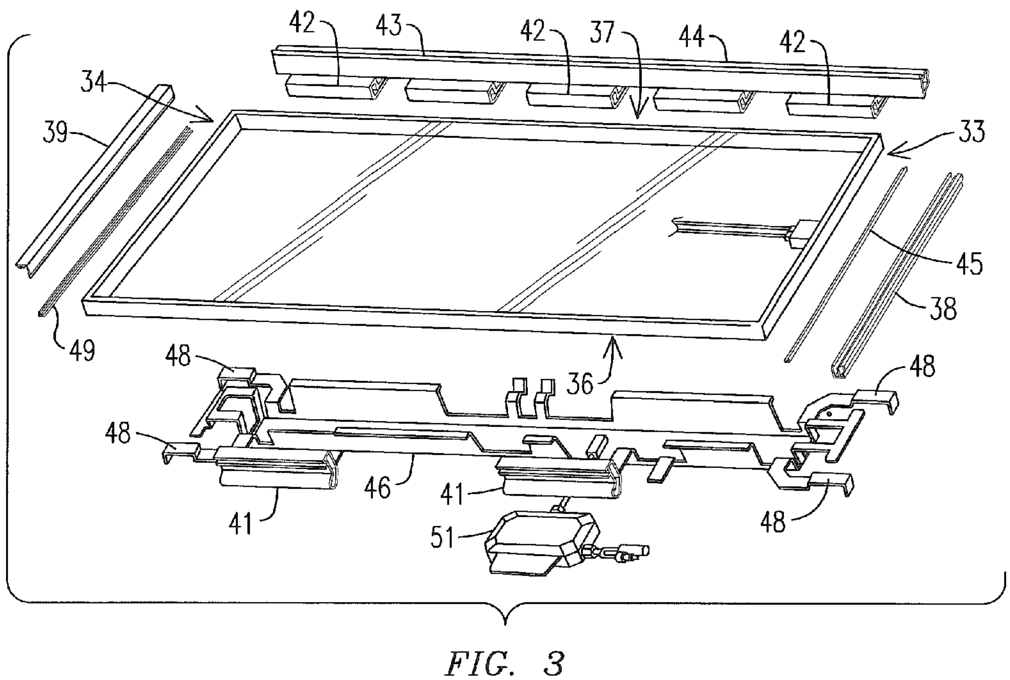

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FIG. 3

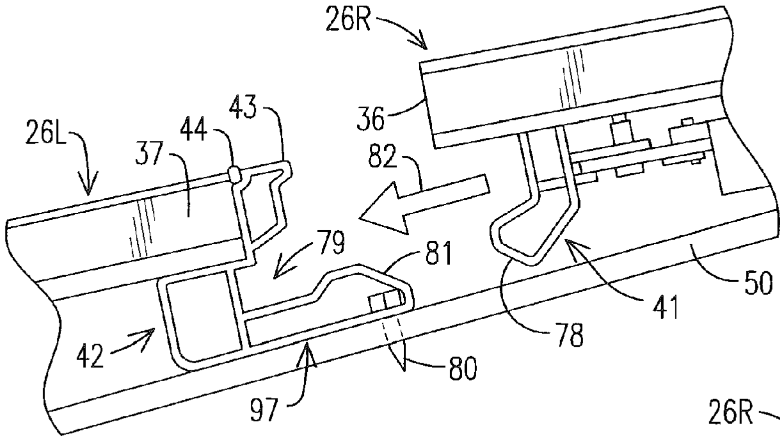

FIG. 4A

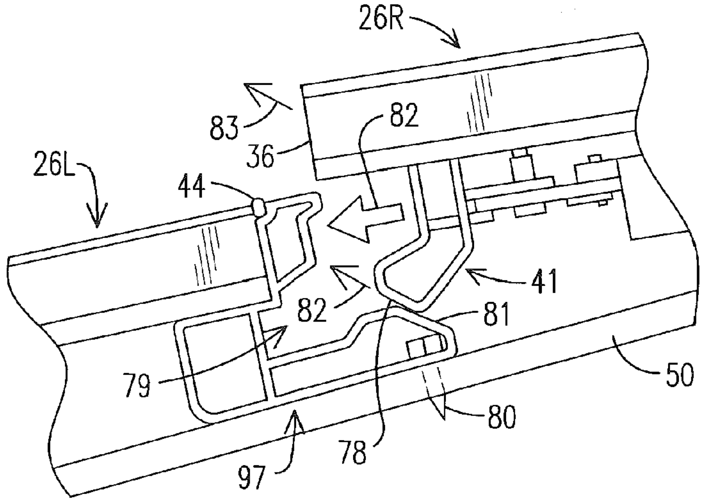

FIG. 4B

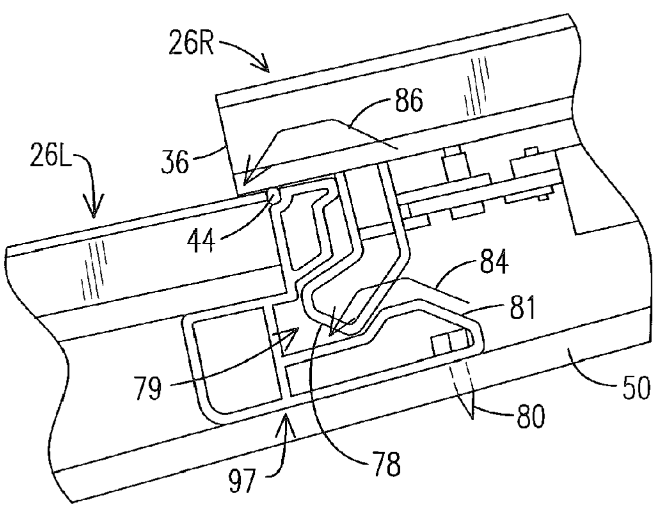

FIG. 4C

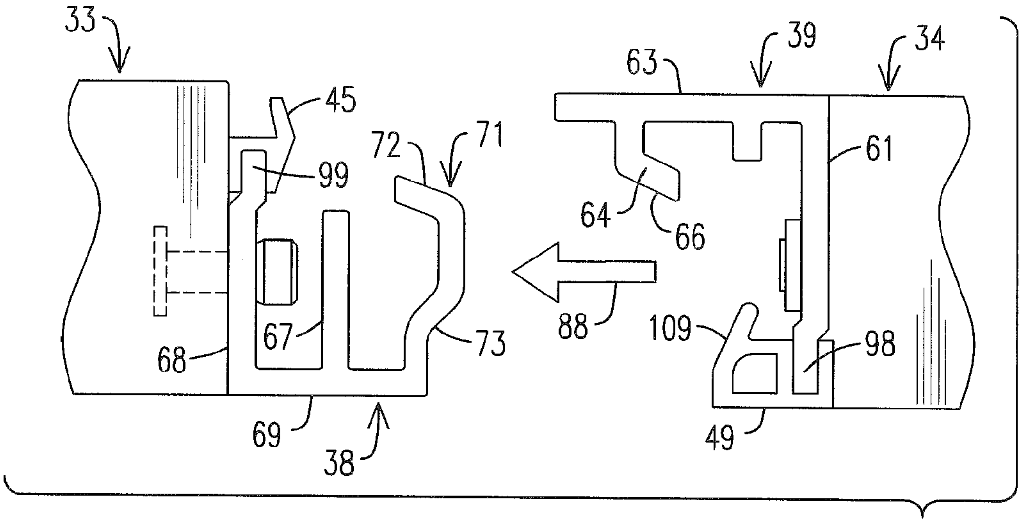

FIG. 5A

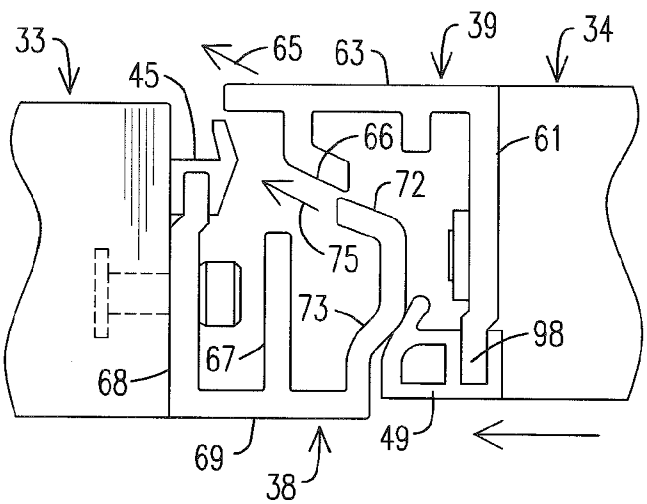

FIG. 5B

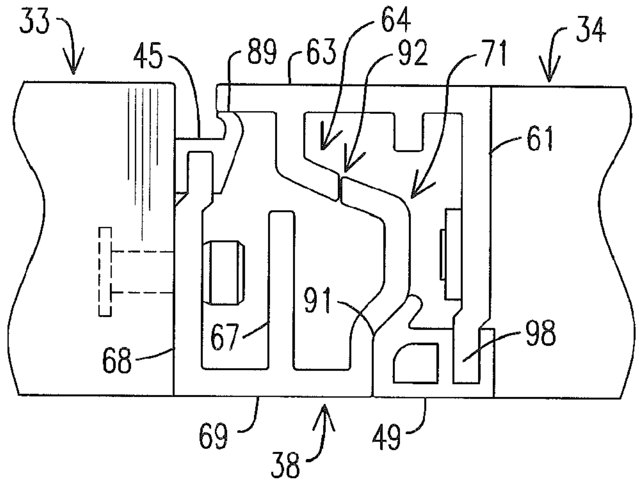

FIG. 5C

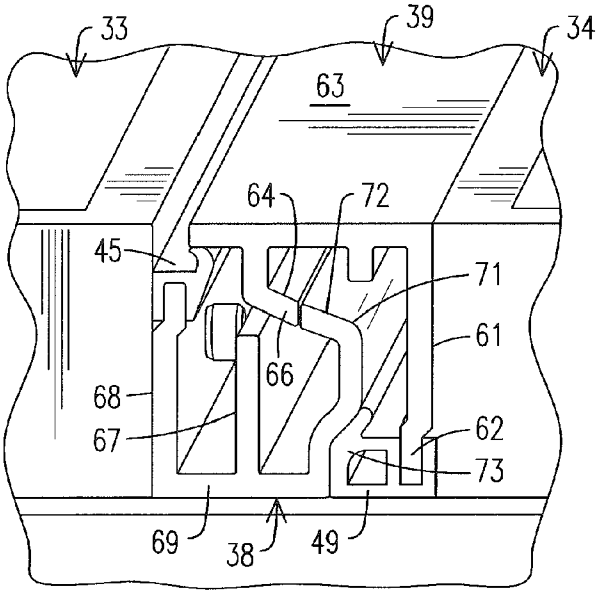
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FIG. 6

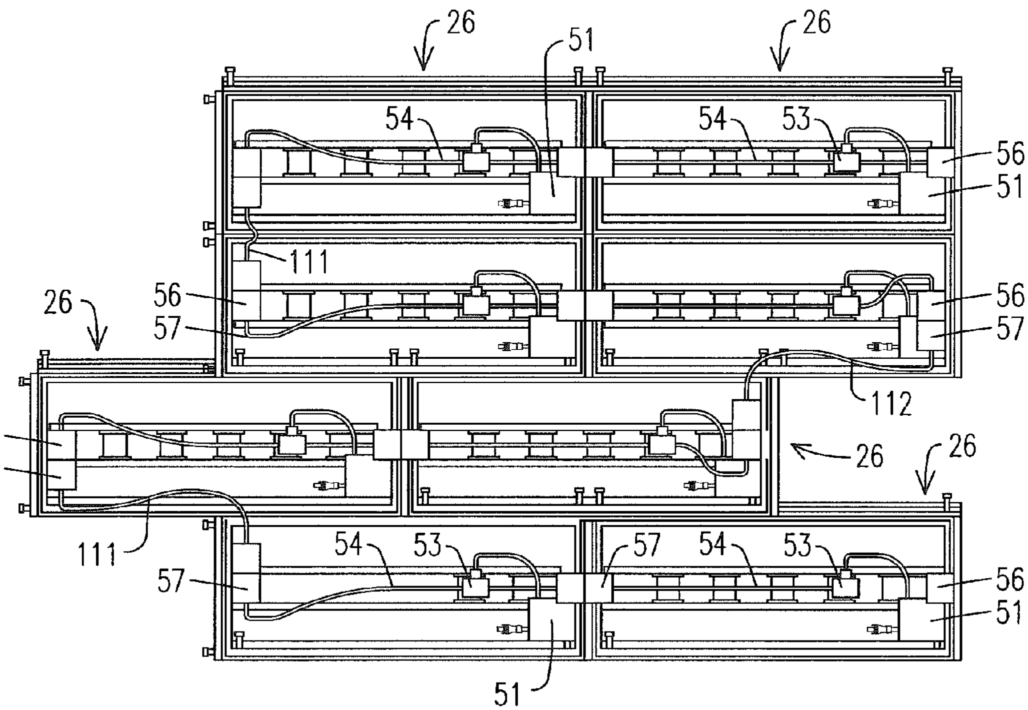
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FIG. 7

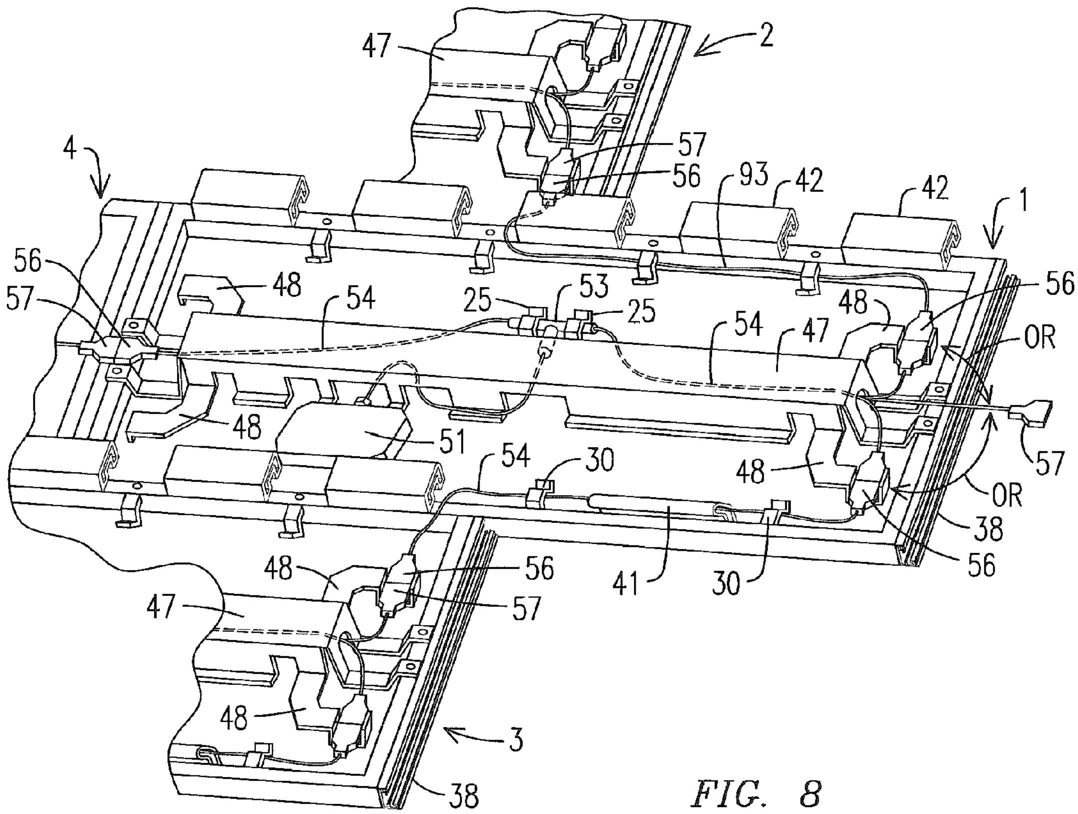
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FIG. 8

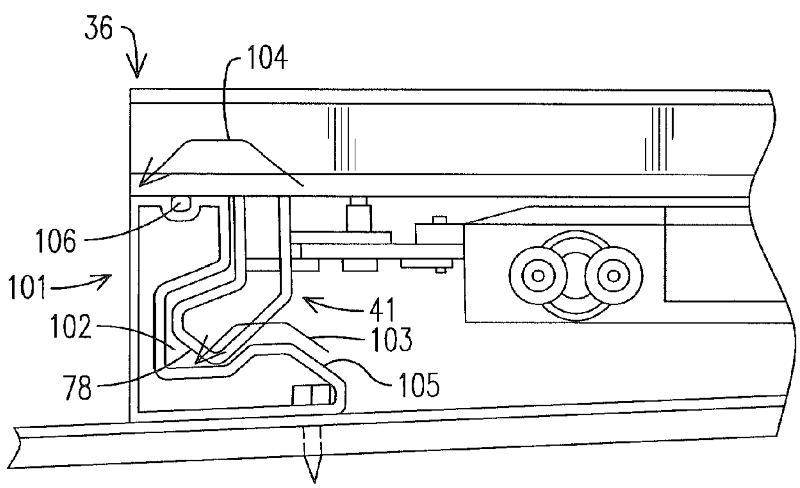
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FIG. 9

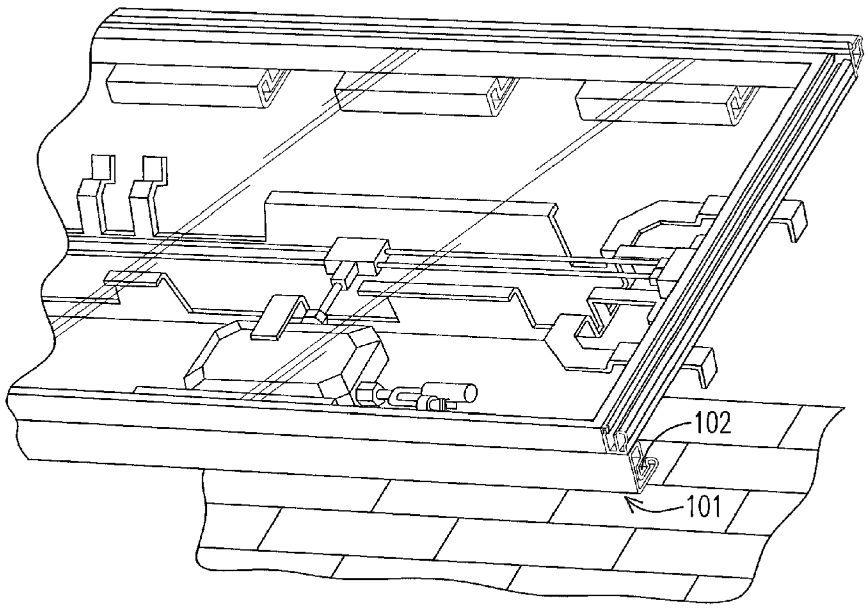

FIG. 10

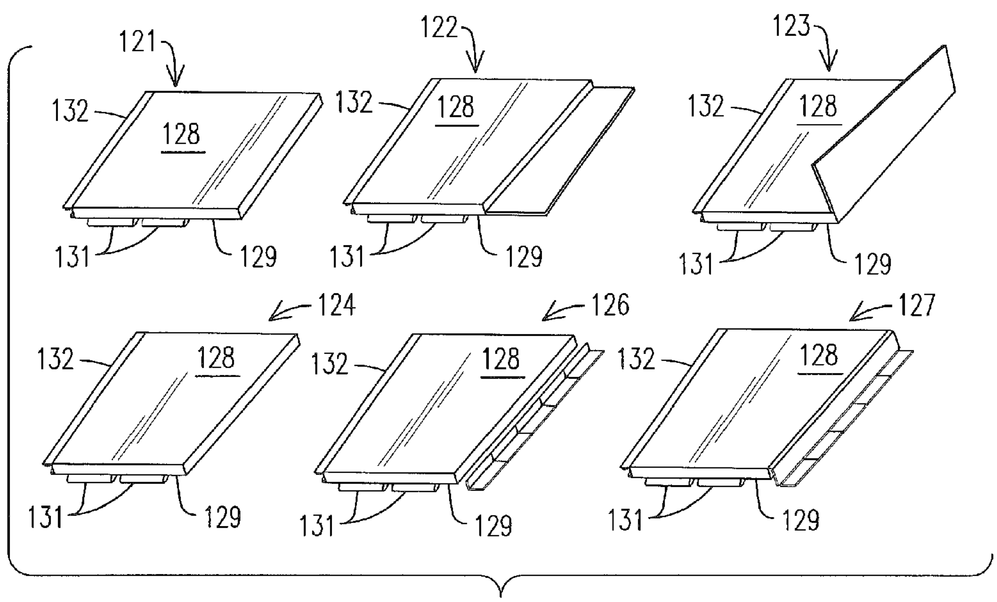

FIG. 11

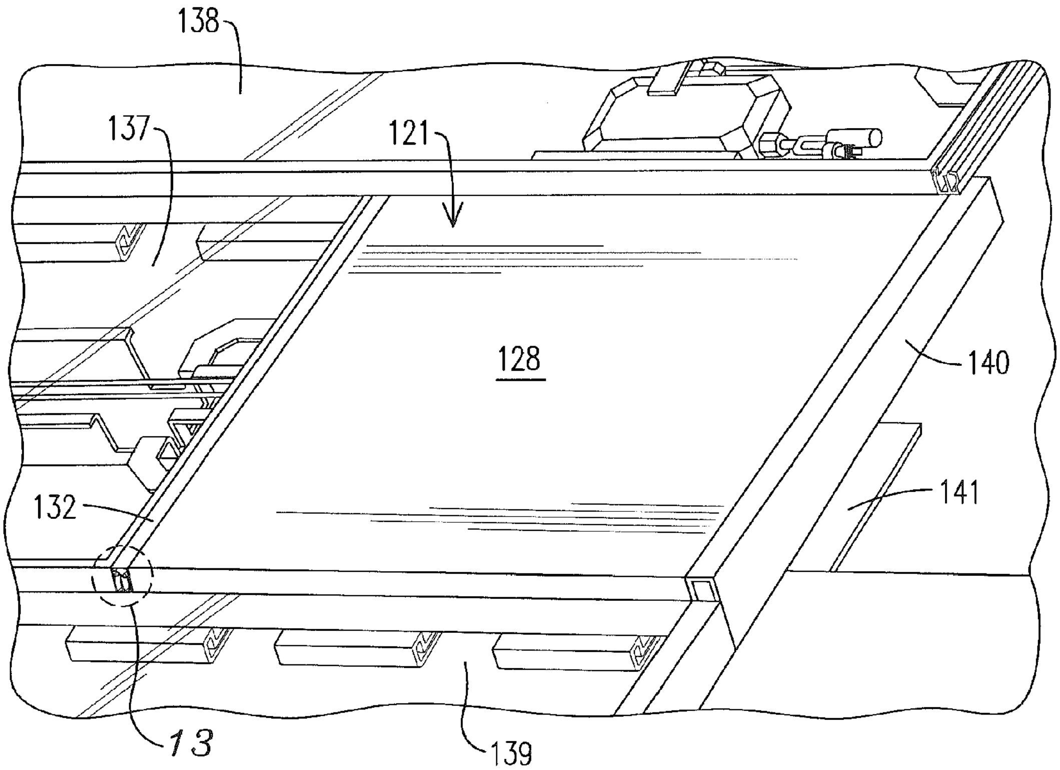
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FIG. 12

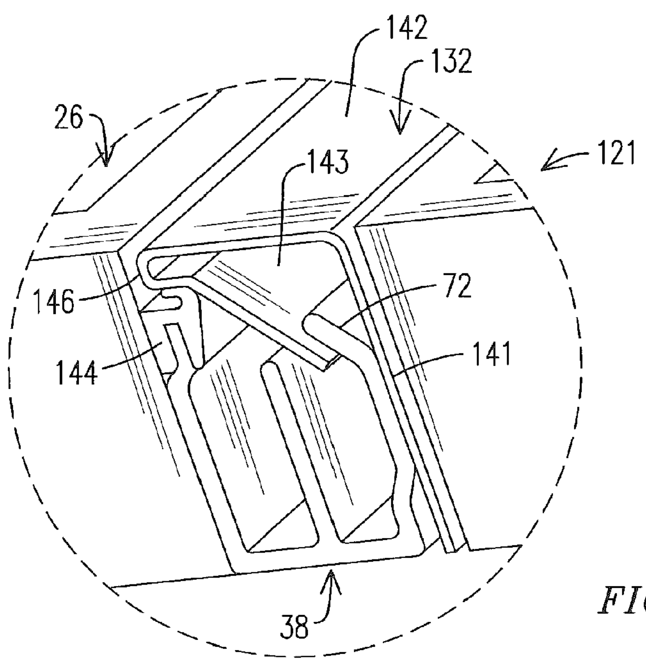
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FIG. 13

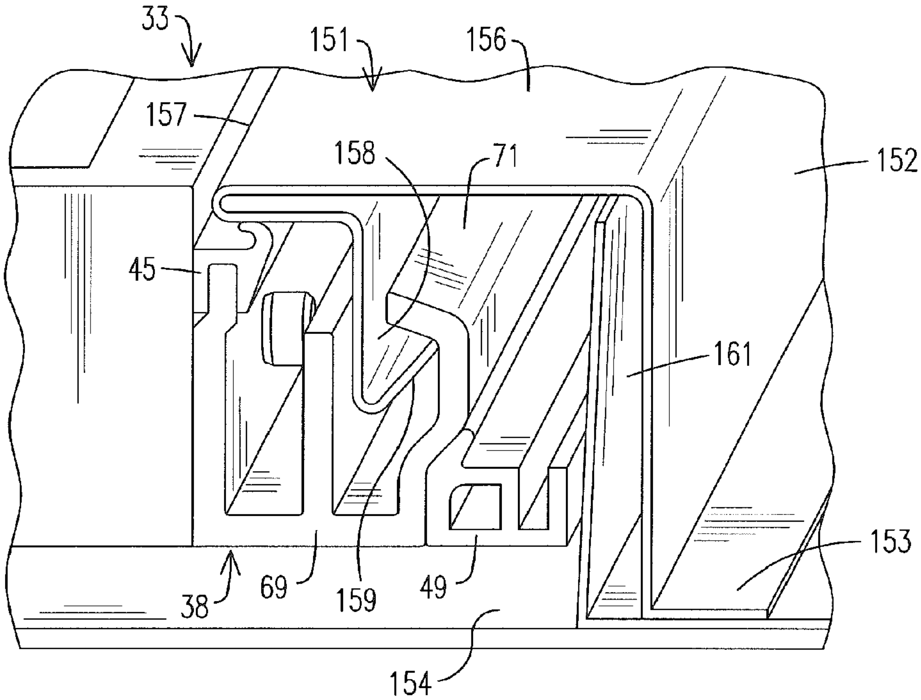

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FIG. 14

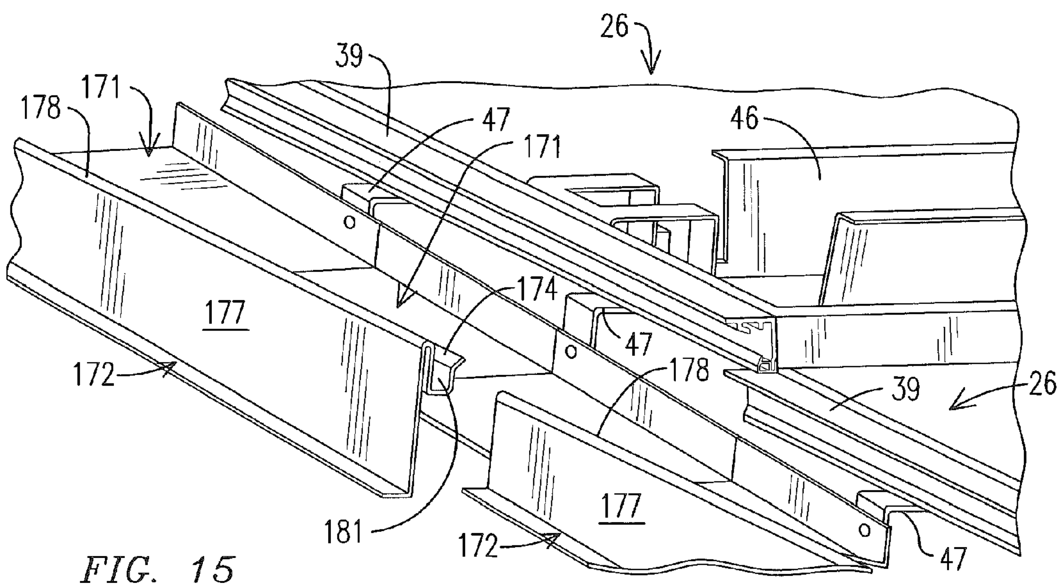

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FIG. 15

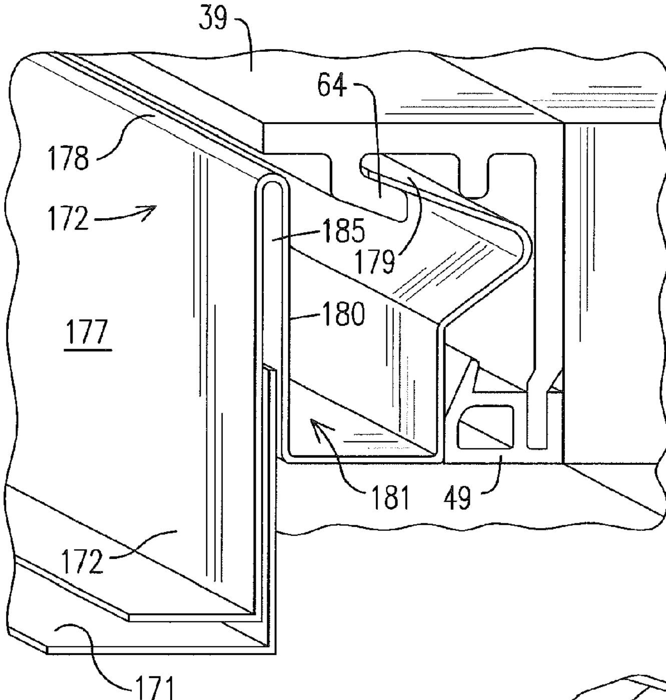

FIG. 16

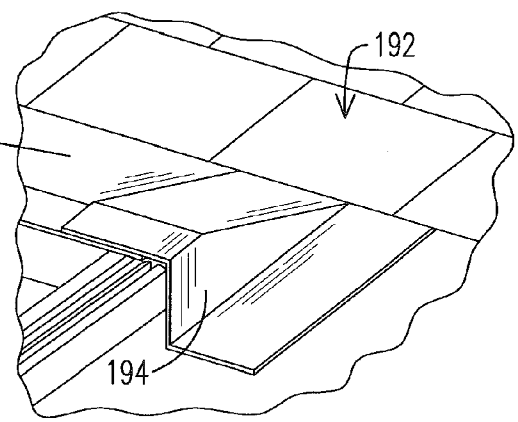

FIG. 18

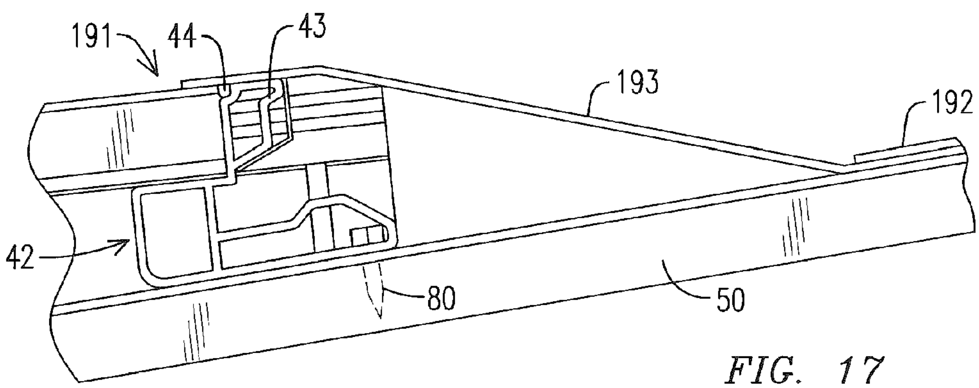

FIG. 17

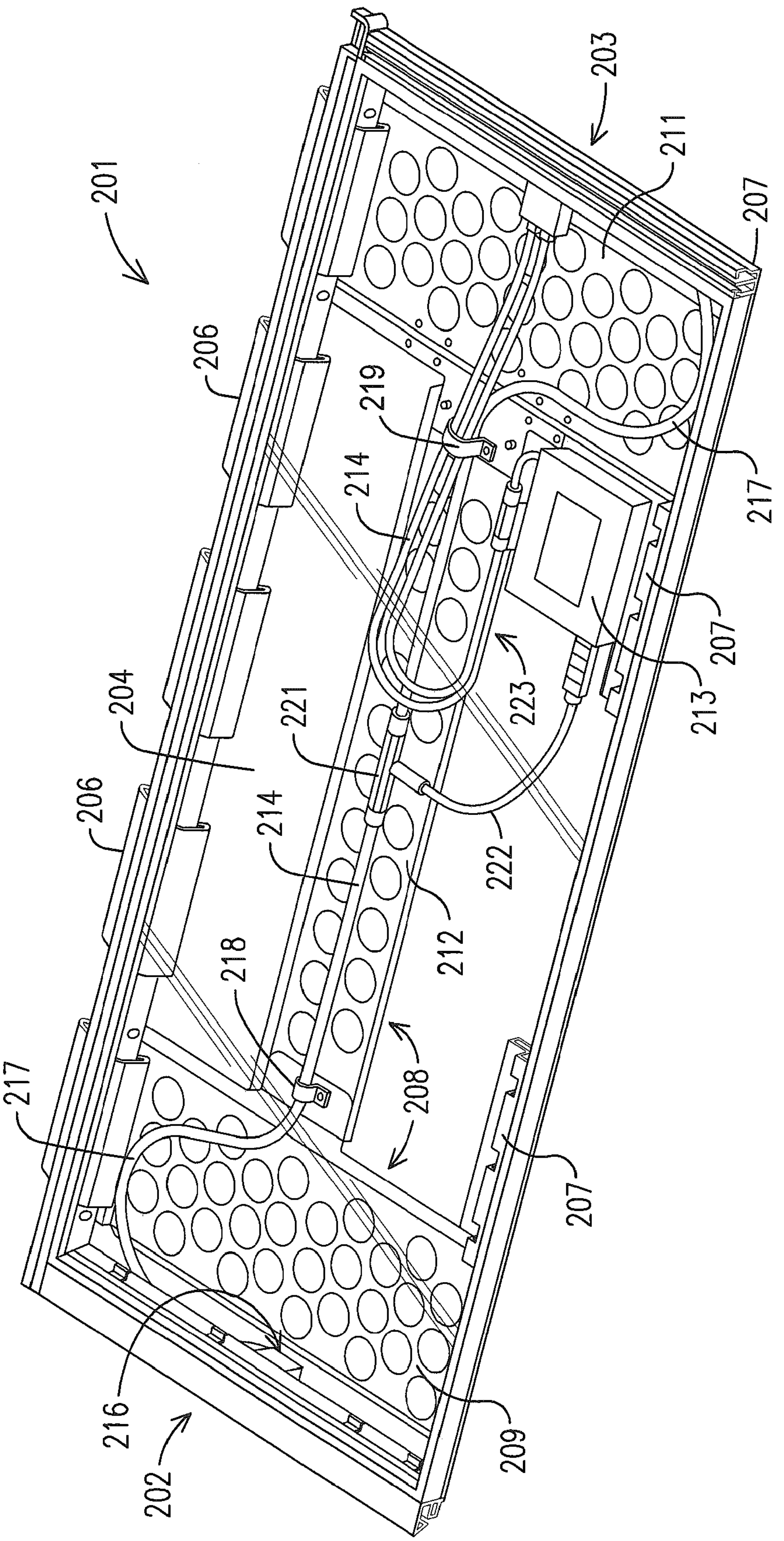
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FIG. 19

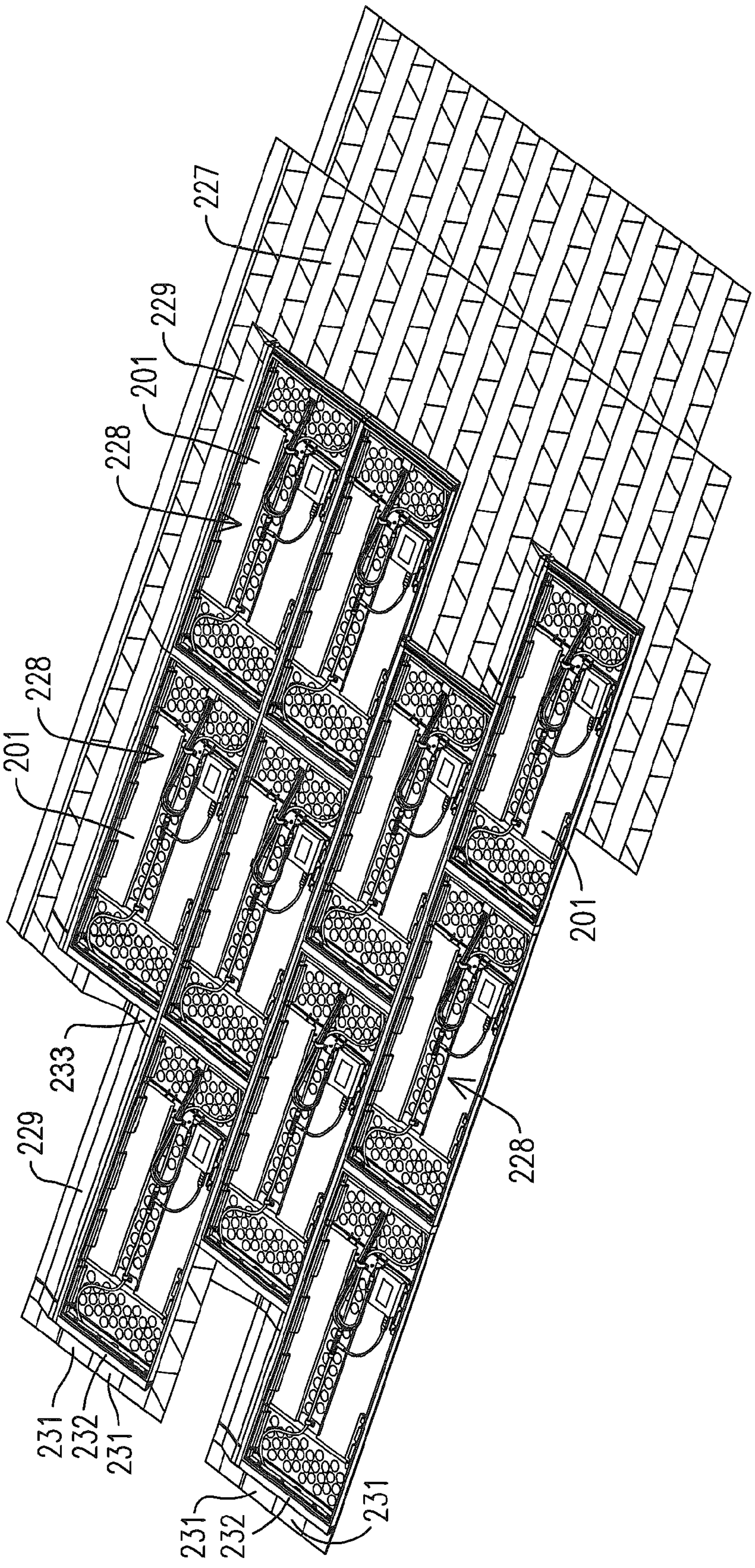
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FIG. 20

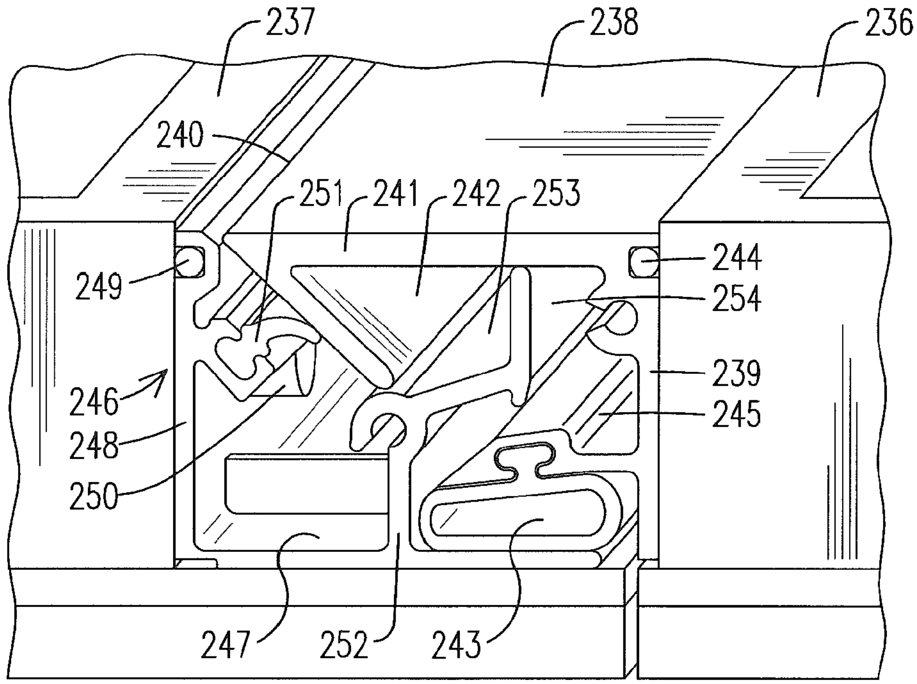
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FIG. 21

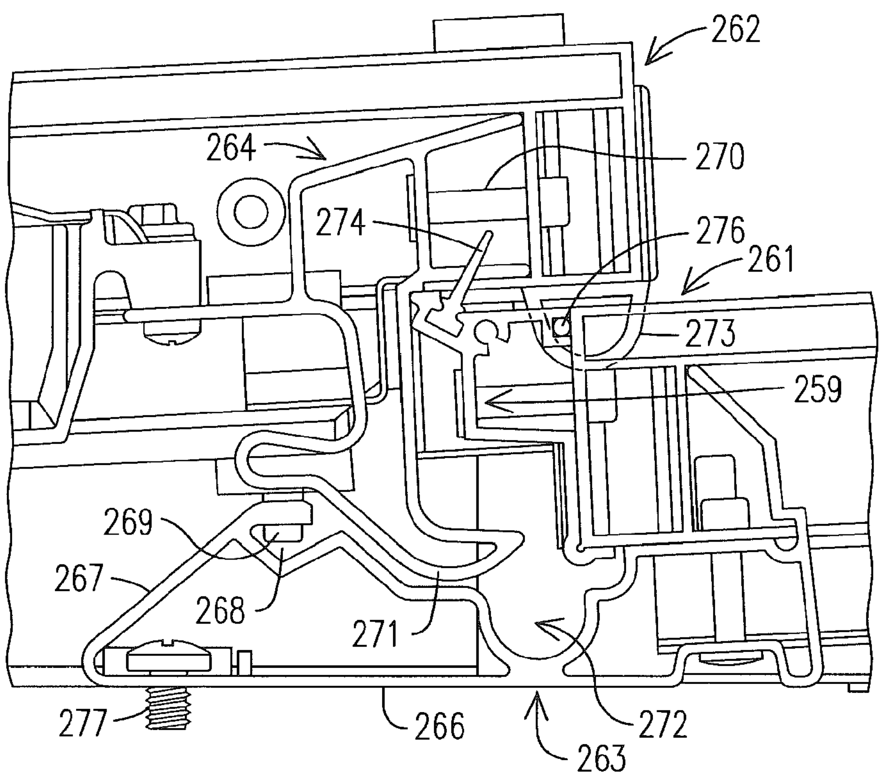
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FIG. 22

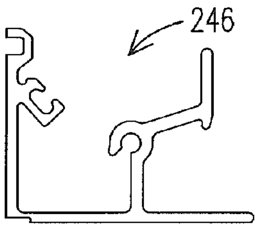

FIG. 23a

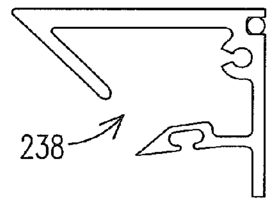

FIG. 23b

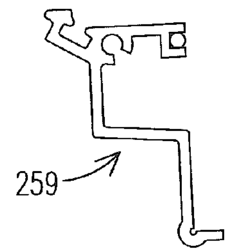

FIG. 23c

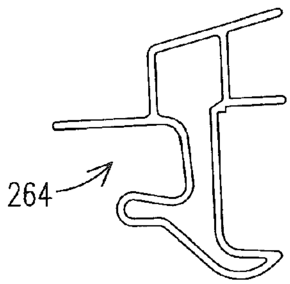

FIG. 23d

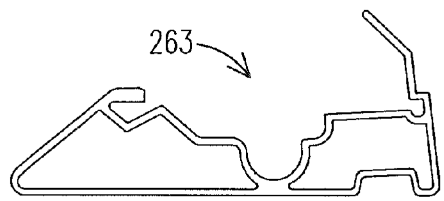

FIG. 23e

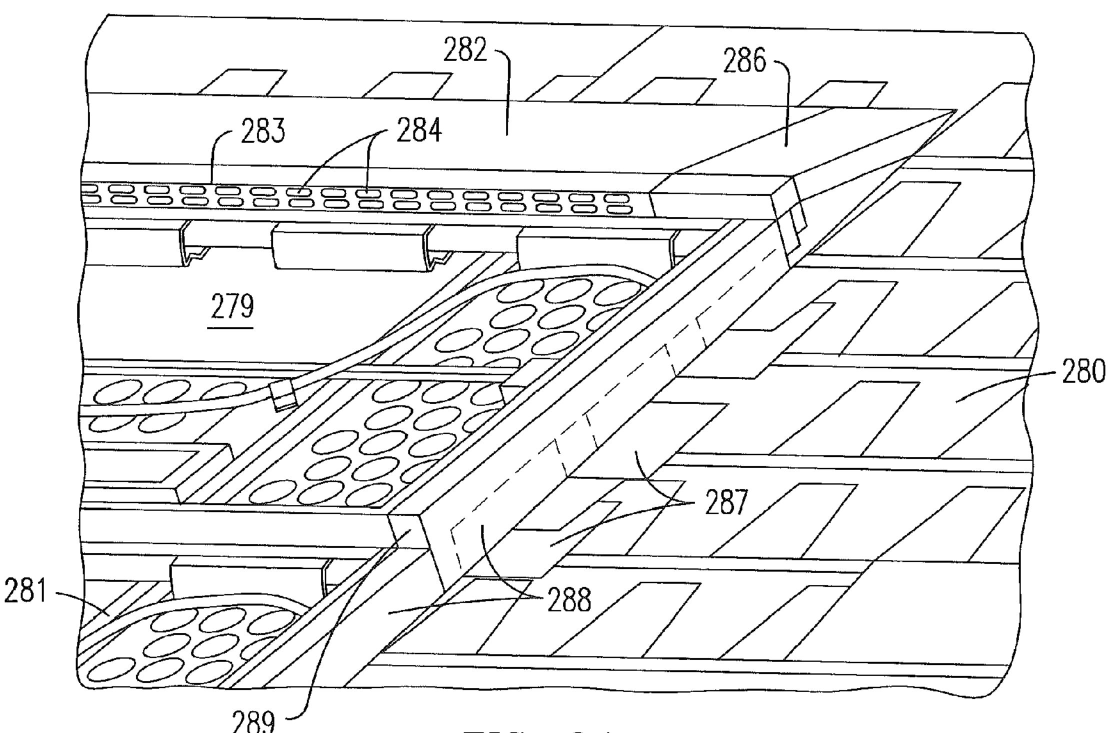

FIG. 24

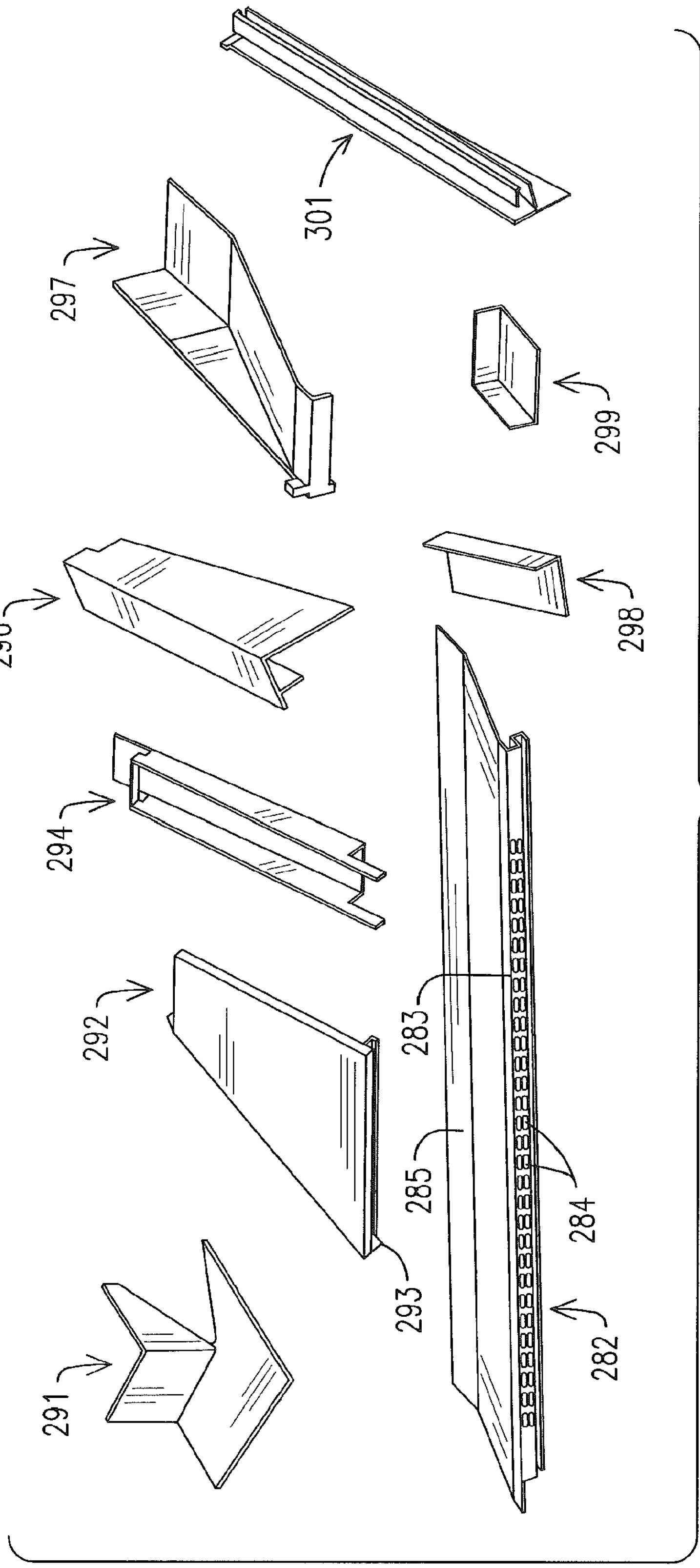

FIG. 25

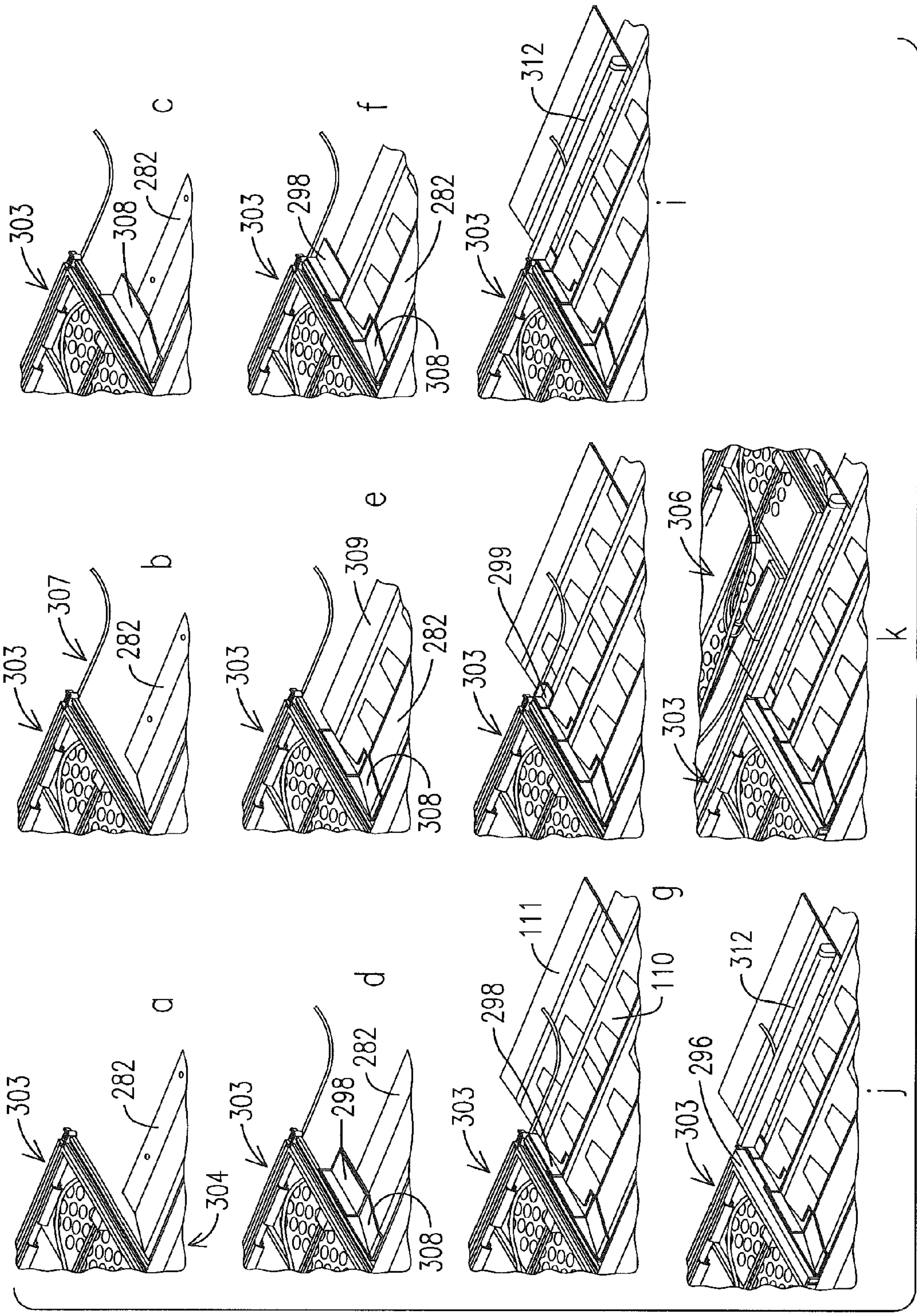

FIG. 26

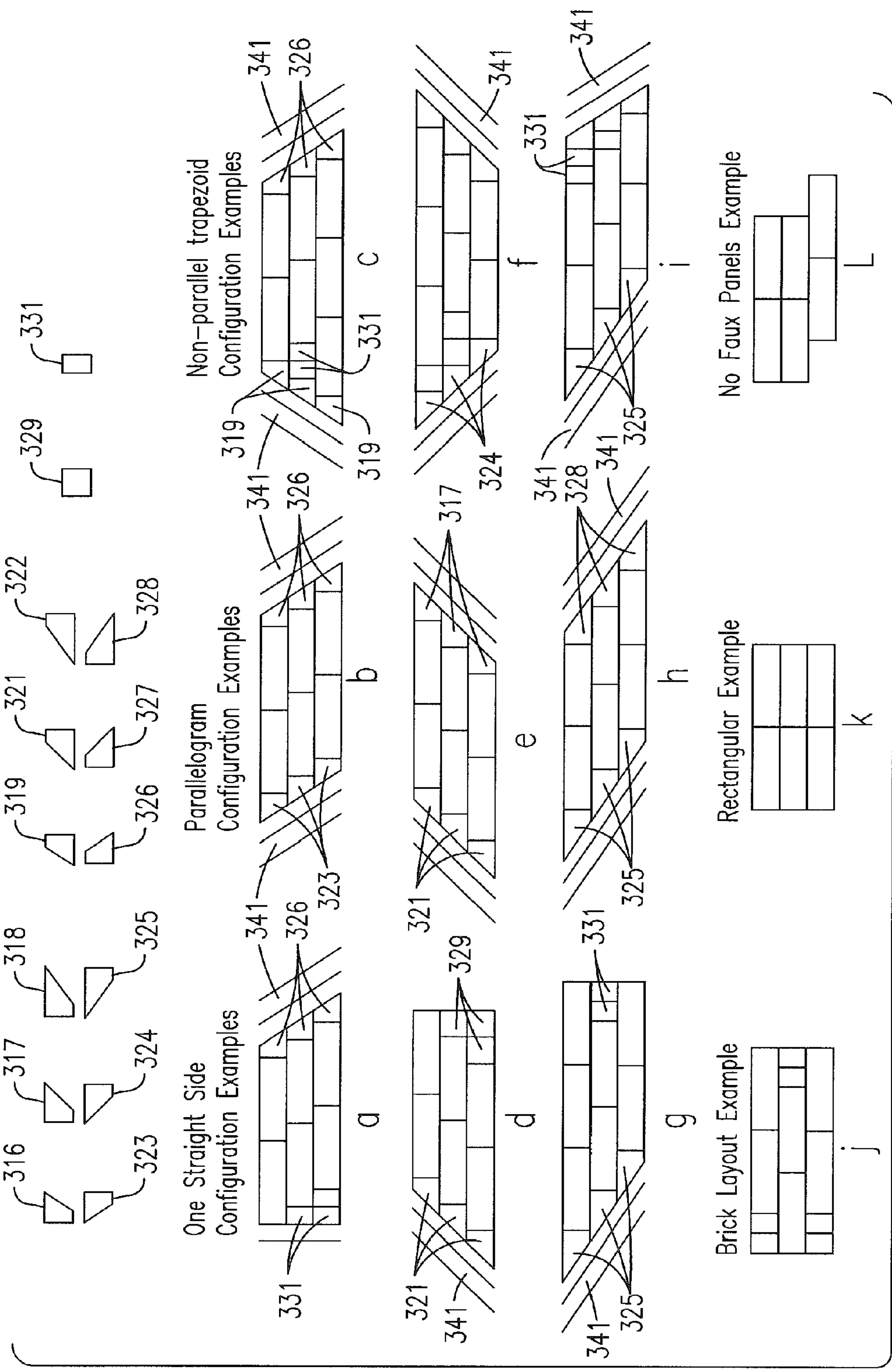
One Straight Side Configuration Examples
Parallelogram Configuration Examples
Non-parallel trapezoid Configuration Examples
Brick Layout Example
Rectangular Example
No Faux Panels Example
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FIG. 27

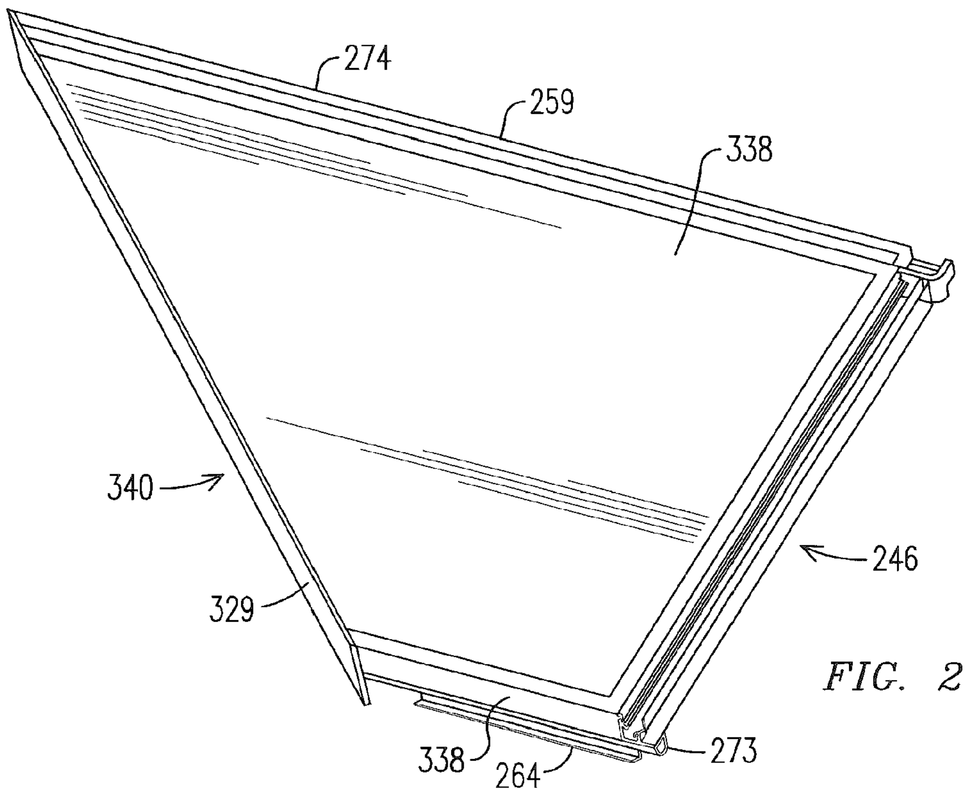


FIG. 28a

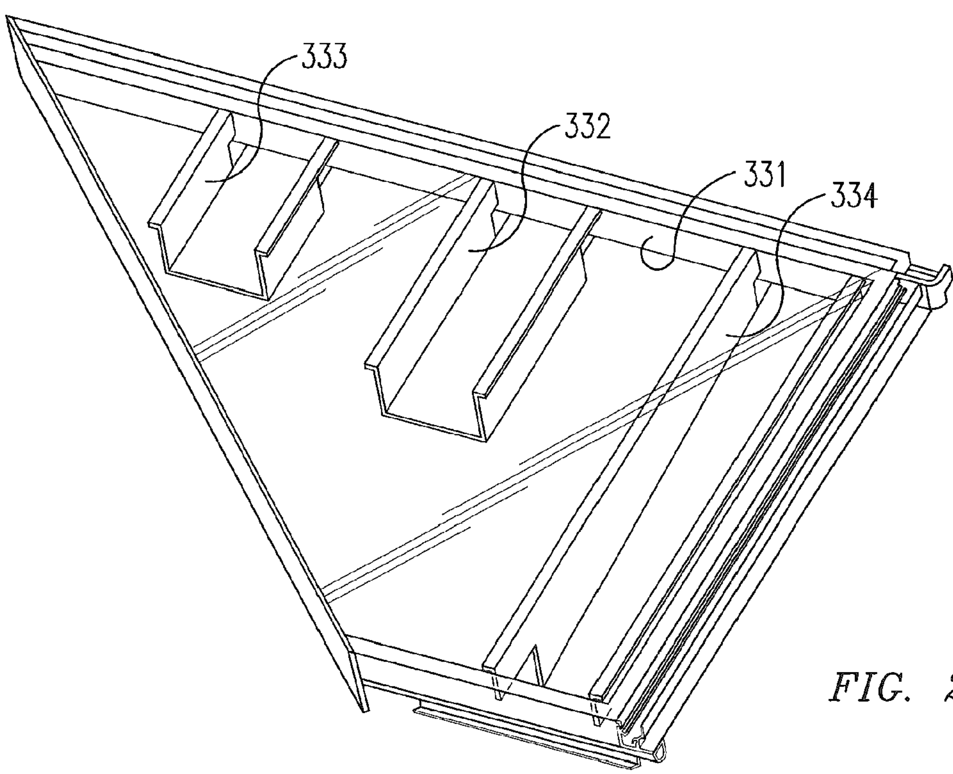
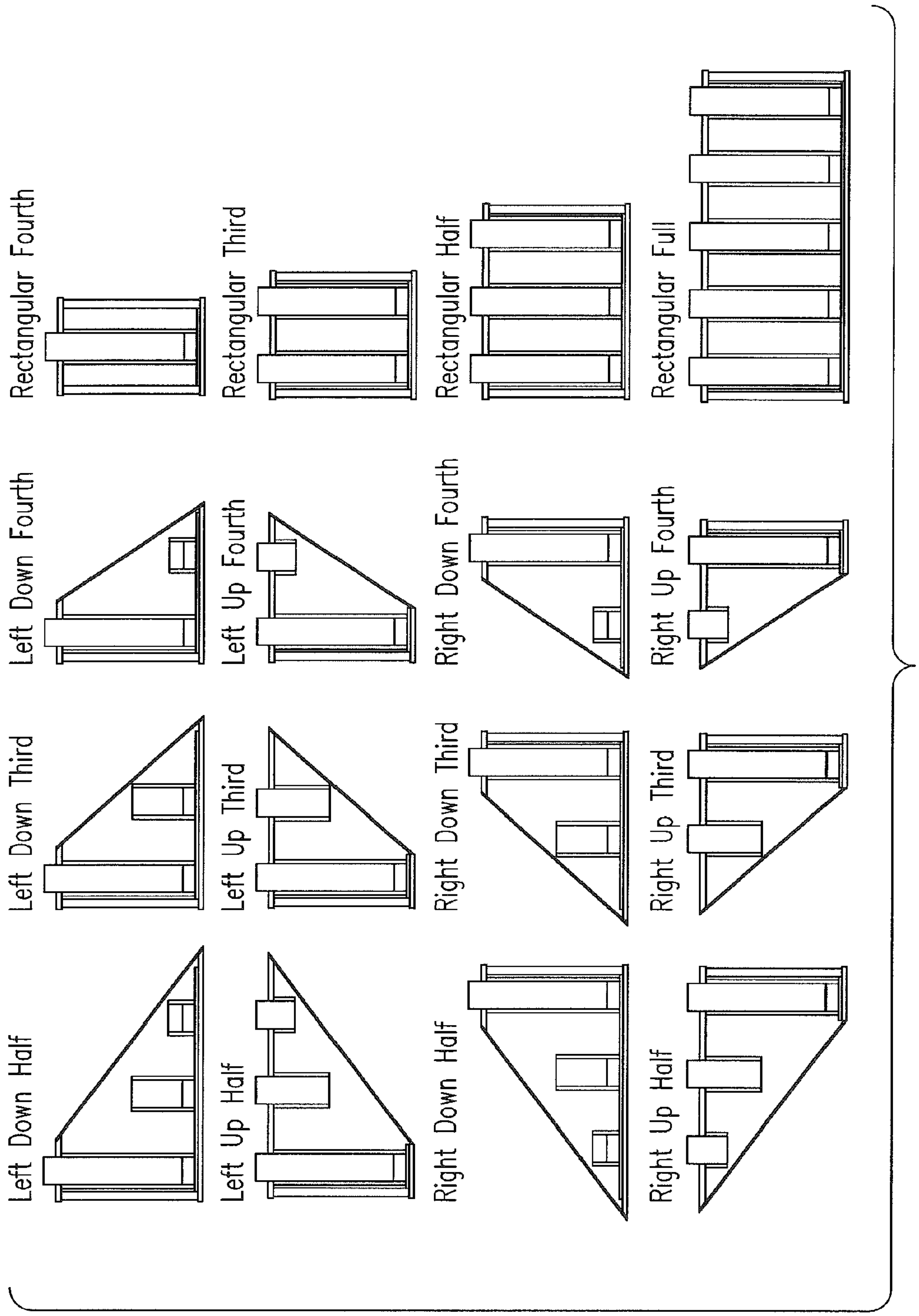


FIG. 28b


Rectangular Fourth
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Rectangular Half
Rectangular Full
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Left Up Fourth
Right Down Fourth
Right Up Fourth
Left Down Third
Left Up Third
Right Down Third
Right Up Third
Left Down Half
Left Up Half
Right Down Half
Right Up Half

FIG. 29

ROOF INTEGRATED PHOTOVOLTAIC SYSTEM

REFERENCE TO RELATED APPLICATIONS

Priority is hereby claimed to the filing dates of U.S. provisional patent application 61/834,527 filed on Jun. 13, 2013 and provisional patent application 61/906,593 filed on Nov. 20, 2013.

TECHNICAL FIELD

This disclosure relates general to solar energy and more specifically to roof mounted solar panel arrays for generating electricity from sunlight.

BACKGROUND

Generating electricity from sunlight has been possible for many years through the use of photovoltaic (PV) cells and panels, PV panel assemblies have been mounted on the roofs of residential homes, but historically such installations have been considered by many to be unsightly and bulky. More recently, so-called "solar shingles" have been available, but these have not tended to be completely successful, particularly with respect to the difficulty of installation and performance issues related to shading or dirt accumulation on the PV panels of the shingles. A need exists for a PV system for the roof of a residential home that is not unsightly, that makes use of highly efficient solar cell technology, that includes shade management to maximize performance when some panels are shaded or dirty, that is integrated with the roof, and that, in addition to generating electricity, provides a roof deck covering that is at least as reliable and long lasting as traditional shingles. It is to the provision of a system that meets these and other needs that the present invention is primarily directed.

SUMMARY

The disclosure of U.S. provisional patent application 61/834,527 filed on Jun. 13, 2013 and the disclosure of U.S. provisional patent application 61/906,539 filed on Nov. 20, 2013 are hereby incorporated by reference in their entireties.

Briefly described, a roof integrated photovoltaic system comprises a plurality of PV panel assemblies that can be arranged in an array on a roof deck to produce electricity when exposed to sunlight. Each PV panel assembly has a rectangular solar panel, left and right end couplers, top edge couplers, and bottom edge couplers. A support rib may be disposed on the back of each PV panel assembly to provide support for the solar panel and form a cable tray to contain and guide electrical wiring and electrical connectors so that the wiring and connectors do not rest on the roof deck. Alternatively, a cable support may be formed without also serving to support the solar panel. To install an array, a worker first attaches a starter bar to the roof deck. Next, a lowermost course of PV panel assemblies is installed by sliding PV panel assemblies together end-to-end along the starter bar causing the end couplers to engage, lock, and seal together. Each PV panel assembly is fastened to the roof deck along its top edge and is electrically interconnected with previously installed panels with to aggregate the electrical output produced by the several panels thereby increasing the power rating of an array with each panel assembly that is installed.

With regard to electrical interconnection of the panels, each PV panel assembly preferably incorporates a micro-

inverter that converts the direct current (DC) output naturally produced by the solar collectors of the panel when exposed to sunlight into an alternating current (AC) output. An AC output for each panel assembly provides numerous advantages including, for instance, its low voltage compared to traditional DC systems and consequent safer installation, its ready compatibility with the public electric grid, its readiness for immediate use to power electrical appliances, and the ability of the micro-inverters to be interconnected with simple parallel connections to increase the power capacity of an installation of PV panel assemblies. Other advantages of a micro-inverter associated with each panel assembly include the anti-islanding features of inverters insuring that installers are not connecting "live" wires during installation, the integrated shade management system of micro-inverters such that one shaded panel does not affect the output of all other panels connected to it, and the ability to track and monitor each PV panel assembly of an installed system, which is not possible with prior art DC systems. There is no need for an installer to worry about combined parallel and serial connections of panels to produce a desired voltage and current capacity. All electrical connections in the present invention are parallel. Microinverter termination also is much easier and straight forward because it follows the same wiring conventions as typical home electrical service and standard subpanels and breakers can be used. Finally, a PV system of the present invention is easily scalable simply by adding additional PV panel assemblies and perhaps a corresponding breaker in the subpanel. The aggregated AC output of the array can be coupled directly to the public electrical grid or otherwise used to power AC appliances within a home.

To form a next higher course of PV panel assemblies, a worker slides PV panel assemblies down the roof deck into engagement with the back edges of a previously installed course of panel assemblies. This causes the front edge couplers of the next higher course to engage and lock with the back edge couplers of the previously installed course of PV panel assemblies. At the same time, the front edge of the panel being installed overlaps the back edge of the previously installed panels and forms a seal to prevent water leakage between courses of panels during rainstorms. Thus, the panels of the array are sealed along both the vertical seams and their horizontal seams to prevent leakage onto the roof deck below. The PV panel assemblies of the next higher course are electrically interconnected together and to the course below so that each course of PV panel assemblies is aggregated to increase the power capacity of the array. Additional courses are added as described until a PV panel array of the desired size and power capacity is obtained.

As part of the installation of a PV array of the present invention, various flashing components are incorporated to flash the tops, sides, bottoms, and other areas of the array. These flashing components direct rainwater onto the top of the array and shed the water down and away from the array making an installed array double as a watertight roofing material in addition to producing electrical energy.

Thus, a roof integrated PV system is now provided that meets the above mentioned and other long felt needs in the industry. The system will be better appreciated and understood upon review of the detailed description set forth below taken in conjunction with the accompanying drawing figures, which are briefly described as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a residential home with a roof integrated PV system according to one aspect of this disclosure.

FIG. 2 is a perspective view of a PV panel assembly configured according to one aspect of the disclosure.

FIG. 3 is an exploded perspective view of the PV panel assembly of FIG. 2 illustrating various components of the PV panel assembly.

FIGS. 4A-4C illustrate one embodiment of front and back edge couplers and show sequentially the coupling together of the back edge couplers of one panel with the front edge couplers of a panel assembly in a next higher course of panel assemblies.

FIGS. 5A-5C illustrate one embodiment of left and right end couplers and show sequentially the coupling together of a left end coupler with a right end coupler during installation of PV panel assemblies in end-to-end relationships.

FIG. 6 is a perspective view showing left and right end couplers engaged and locked together and illustrates the sealing gaskets compressed within the locked together couplers.

FIG. 7 is a top plan and partially transparent view of an array of PV panel assemblies according to one embodiment of the disclosure illustrating electrical connections between the micro inverters of the panels.

FIG. 8 is a bottom perspective view of a portion of the array of FIG. 7 illustrating the support rib of this embodiment and its various features for containing and restraining electrical cables and electrical connectors.

FIG. 9 is an edge view of the front edge portion of a lowermost course of a PV array illustrating use of a starter strip coupler for the lowermost installed course of PV panel assemblies.

FIG. 10 is a perspective view of a PV panel assembly of the lowermost course showing its connection to the starter strip coupler along the front edge of the array.

FIG. 11 illustrates several variations of dummy panels for filling gaps at the ends of an installed array of PV panel assemblies according to one embodiment of the disclosure.

FIG. 12 is a perspective view of a section of the edge of an installed array of PV panel assemblies showing a dummy panel filling a gap formed by offset PV panel assemblies.

FIG. 13 is a perspective view illustrating connection of a dummy panel to the right end coupler of a PV panel assembly.

FIG. 14 is an enlarged perspective view illustrating one embodiment of a right end counter flashing for flashing the PV array to the roof on the right edge of the PV array.

FIG. 15 is a perspective view of illustrating one embodiment of a left end step flashing and counter flashing for flashing the array to the roof on the left end of the PV array.

FIG. 16 is an enlarged perspective showing the connection of the left end counter flashing of FIG. 12 to the left end coupler of a PV panel assembly.

FIG. 17 is a side view along the back edge of a PV array illustrating one embodiment of flashing for the back edge of the array.

FIG. 18 is a perspective view of a rear corner of a PV array illustrating one embodiment of a corner flashing component for flashing the array to the roof at its back corners.

FIG. 19 is a perspective view of a PV panel assembly configured according to an alternate embodiment.

FIG. 20 is a perspective view of an array of PV panel assemblies of FIG. 19 installed on a roof.

FIG. 21 is a perspective view illustrating an alternate embodiment of left and right end couplers.

FIG. 22 is and end view illustrating an alternate embodiment of the top and bottom edge couplers.

FIGS. 23*a* through 23*e* are end views illustrating the five aluminum extrusions used to fabricate the left and right end couplers and the top and bottom edge couplers of FIGS. 21 and 22.

FIG. 24 is a perspective view showing a portion of an installed PV panel array and illustrating alternate PV panel assemblies and some of the flashing components used to prevent water penetration beneath the panel assemblies.

FIG. 25 illustrate nine (9) formed metal components that are used to fabricate all needed flashing components for a PV system installation such as that shown in FIG. 24.

FIG. 26 shows in sequence (a-k) the installation of various flashing components and particularly the inside corner flashing component shown in FIG. 25.

FIG. 27 illustrates a set of faux. PV panels according to an alternate configuration for creating an aesthetically pleasing edge along an installed PV panel array.

FIGS. 28*a* and 28*b* illustrate a faux panel construction according to an alternate embodiment.

FIG. 29 illustrates in more detail the various faux panel configurations showing the relationship of their supports to their various shapes.

DETAILED DESCRIPTION

Referring now in more detail to the drawing figures, wherein like reference numerals indicate like parts throughout the several views, FIG. 1 illustrates a residential home 22 having a roof 23 with a roof integrated photovoltaic system 21 installed thereon according to one embodiment of the present invention. The roof integrated photovoltaic system 21 comprises a plurality of PV panel assemblies 26 mounted to the roof to form a PV array. The panels, when installed, define front-to-back edge connections 28 and end-to-end connections 27, which will be described in more detail below. Dummy panels 29 may be installed along the edges of the PV array to fill gaps along the edges of the array so that the array presents a neater appearance on the roof. The PV panel assembles may include corresponding micro-inverters that convert the original DC voltage produced by the solar cells of the PV panel assemblies to an AC voltage. The AC outputs of the micro-inverters of the PV panel assemblies are electrically connected together to result in an aggregated AC voltage and power rating of the array and this aggregated AC voltage may be electrically connected to the public electrical grid or otherwise used by a homeowner to power home appliances.

FIGS. 2 and 3 show one of the PV panel assemblies of this embodiment in its assembled configuration (FIG. 2) and in an exploded configuration (FIG. 3). In these figures, a solar panel comprises a field of solar cells 31 surrounded and supported by a frame 32, which may be an aluminum C-channel frame. Most of the field of solar cells is cut away in FIGS. 2 and 3 to reveal components of the system beneath the solar panel. In practice, the field of solar cells is dark and opaque and faces upwardly to be exposed to sunlight and thereby generate electricity. The solar panel in this embodiment is a commercially available product that may be obtained from a variety of sources such as, for example, TSMC Solar of San Jose, Calif. and STION of San Jose, Calif. The solar panel is generally rectangular in shape and has a right end 33, a left end 34, a front edge 36, and a back edge 37.

Aright end coupler 38 is fixed to and extends along the right end 33 of the solar panel and a left end coupler 39 is fixed to and extends along the left end 34 of the solar panel. As detailed below, the right and left end couplers are configured to lock together and form a seal when two PV panel assemblies are urged together in an end-to-end relationship with each other. A gasket 45 (FIG. 3) is associated with the right end coupler 38 and a gasket 49 (FIG. 3) is associated with the left end coupler 39. As discussed below, the gaskets 45 and 49 are configured to form a seal against water penetration along an end-to-end connection of PV panel assemblies in a PV array.

Front edge couplers **41** are attached at the front edge **36** of the solar panel and project generally downwardly therefrom. In the illustrated embodiment, the front edge couplers do not extend along the full length of the front edge **36** but instead comprise two spaced apart couplers as shown. Back edge couplers **42** are attached at spaced intervals along the back edge of the solar panel and project generally downwardly therefrom. The front edge couplers **41** and the back edge couplers **42** are configured as detailed below to lock together when two PV panel assemblies are urged together in a front-edge-to-back-edge relationship. A seal strip **43** along the back edge of the solar panel carries an elongated gasket **44** (FIG. **3**) that forms a seal against water penetration along a front-edge-to-back-edge connection of PV panel assemblies, as discussed in more detail below.

A micro-inverter **51** is mounted beneath the solar panel and its inputs are electrically connected to the DC output of the solar panel. The micro-inverter **51** converts the DC voltage produced by the solar panel to AC voltage at its plug **52**. The AC voltage output of the micro-inverter is coupled through a splitter **53** to an electrical cable **54** that extends beneath and along the length of the solar panel. The electrical cable **54** terminates at the right end of the solar panel in a male electrical connector **56** and terminates at the left end of the solar panel in a female electrical connector **57**. Of course, the locations of the male and female electrical connectors can be reversed or otherwise changed from that shown and described herein with the same or equivalent results.

In this embodiment, a support rib **46** is attached to the bottom of the solar panel and extends therealong from the right end **33** to the left end **34** of the solar panel. The support rib **46** extends downwardly from the solar panel a distance sufficient to rest on a roof deck below and thereby provide structural support to the solar panel when the PV panel assembly is installed on a roof. A cable tray is formed between spaced apart walls of the support rib **46** and is configured to enclose electrical cables of the PV panel assembly so that they do not rest directly on a roof deck below. The cable tray may have ends that define tabs **47**. Further, the support rib **46** is formed with various clips **48** that function to clip the electrical connectors and cables of the system to the bottom of the solar panel, again preventing them from resting directly on a roof deck below. Retaining the cables and connectors above the roof deck is important because cables and connectors resting directly on the roof deck can become chafed over time and thereby represent an electrical hazard.

FIGS. **4A-4C** illustrate in more detail one embodiment of the front edge and back edge couplers of the system and how they lock together when two PV panel assemblies are urged progressively together in a front-edge-to-back-edge relationship. The PV panel assembly on the left (**26**L) in these figures is a previously installed PV panel assembly of a lower course of PV panel assemblies and the PV panel assembly on the right (**26**R) is a PV panel assembly of a next higher course. PV panel assembly **26**L has back edge **37** to which a set of back edge couplers **42** are fixed with rivets or other appropriate fasteners. The seal strip **43** extends along the back edge **37** of the PV panel assembly **26**L and carries gasket **44**, which may be a spaghetti gasket, a string gasket, or other appropriate compressible gasket.

The back edge coupler **42** define a rearwardly extending projection **97** that rests on a roof deck **50**. The PV panel assembly is secured to the roof deck with screws or other appropriate fasteners **80** that extend through the back edge couplers and into the roof deck below. The rearwardly extending projection **97** further defines an inclined ramp **81** along its back edge and a slot **79** inboard of the ramp **81**. PV panel assembly **26**R has a front edge **36** and a set of front edge couplers **41** mounted just beneath and inboard of the front edge **36**. Each front edge coupler is formed to define a forwardly facing tongue **78** sized to be received within the slot **79** of a back edge coupler **42**.

FIG. **4**A shows the PV panel assembly **26**R being slid down the roof deck **50** in the direction of arrow **82** toward the back edge of the PV panel assembly **26**L. In FIG. **4**B, the PV panel assembly **26**R has moved closer to the PV panel assembly **26**L and the tongue **78** of the front edge coupler **41** has engaged the projection **97** of the back edge coupler **97**. Further, the tongue **78** is seen riding up the ramp **81** of the back edge coupler in the direction indicated by arrow **82** as the PV panel assembly **26**R is urged toward the PV panel assembly **26**L. In this regard, the tongue **78** may be thought of as a ramp follower. This, in turn, causes the front edge of the solar panel of the assembly **26**R to rise progressively upwardly as indicated by arrow **83**. The front edge continues to rise until the bottom of the front edge is elevated slightly above the top of the back edge of PV panel assembly **26**L when the tongue **78** reaches the top of the ramp **81**.

FIG. **4**C illustrates that as the tongue of the front edge coupler moves beyond the land at the top of the ramp **81**, the tongue **78** falls downwardly into the slot **79** of the back edge coupler, where the tongue is captured. The downward motion of the tongue causes the front edge of the PV panel assembly **26**R to move downwardly until its underside engages and compresses the gasket **44**. The motion of the tongue and the front edge is illustrated by arrows **84** and **86** in FIG. **4**C. This forms a seal against water leakage along the horizontal interface between the two PV panel assemblies. In addition, an overlap is formed between front edge of the PV panel assembly **26**R and the back edge of the PV panel assembly **26**L to define a water shed, which promotes cascading and further inhibits leakage of water during rain.

It will be seen from the forgoing that a course of PV panel assemblies can easily be installed above a previously installed course of PV panel assemblies by sliding the PV panel assemblies of the new course into front-edge-to-back-edge engagement with the panels of the previously installed course and urging them together. This causes the two panels to lock together and form a seal along their interface. The new panel can then be secured to the roof deck with a screw as shown at **80** in FIGS. **4**A-**4**C in preparation for a next higher course of PV panel assemblies or back flashing. The locations along the back edge of the five back edge couplers **42** (FIG. **3**) and the locations along the front edge of the two front edge couplers **41** facilitate staggered installation of PV panel assemblies from course to course. More specifically, the PV panel assemblies of a higher course can be shifted right or left during assembly relative to PV panel assemblies of a lower course until their front edge couplers align with different pairs of back edge couplers on the panels of the lower course. In this way, the seams between the panels of the higher course are shifted and do not align with those of the panels of the lower course, rather like traditional asphalt shingles.

FIGS. **5A-5C** illustrate the joining together of two (a first and a second) PV panel assemblies of this embodiment in a side-to-side relationship while installing a PV array according. In FIG. **5**A, the right end **33** and left end **34** of two like PV panel assemblies are shown being moved toward one another as indicated by arrow **88**. A right end coupler **38** is attached to the right end **33** with appropriate fasteners and extends along the right end **33** of the first PV panel assembly. Similarly, the left end coupler **39** is attached to the left end **34** with appropriate fasteners and extends along the left end **34** of the second PV panel assembly.

The right end coupler **38** is preferably formed of extruded aluminum or other appropriately rigid material and is profiled to define a vertical leg **68** that is fixed to the right end **33** of its solar panel and a horizontal leg **69** projecting from the bottom of the vertical leg **68**. The top of the vertical leg **68** is slightly offset to define an elongated flange **99** that is sized to receive the gasket **45** associated with the right end coupler **38**. The gasket in the preferred embodiment has an upstanding fin, but this gasket may take on a variety of different substitute shapes that obtain the same result. A wall projects upwardly from the end of the horizontal leg **69** and is formed to define a sealing surface **73** at its lower extremity and a locking tab **71** at its upper extremity. The locking tab **71** defines a ramped top surface **72**. A structural rib **67** may be formed along the right end coupler if desired to improve its rigidity and strength.

The left end coupler **39** also is preferably formed of extruded aluminum and has a vertical leg **61** that attaches to the left end of the solar panel with rivets or other appropriate fasteners. The vertical leg **61** is offset along its bottom edge to define an elongated flange **98** sized to receive the gasket **49** associated with the left end coupler **39** and having an upwardly extending fin **109**. A horizontal leg **63** projects from the top of the vertical leg **61** and is profiled with a locking tab **64** projecting downwardly from its underside. The locking tab **64** defines a ramped bottom surface **66**. A structural rib also may be formed along the bottom side of the horizontal leg **63** to add rigidity and strength to the left end coupler. The gasket **49** is received onto and held in place by the flange **98** and, in the preferred embodiment, is formed with an upwardly projecting fin, although other gasket configurations are possible.

FIG. **5**B shows the two PV panel assemblies being urged closer together in an end-to-end relationship. The ramped bottom surface **66** of the left end coupler has engaged the ramped top surface **72** of the right end coupler and is riding up the ramped surface **66** in the direction of arrow **75**. In this regard, the ramped bottom surface **66** may be thought of as a ramp follower. This, in turn, causes the horizontal leg **63** of the left end coupler to move progressively upwardly in the direction of arrow **65**, which generally elevates it above the gasket **45**. Further, in FIG. **59**, the left end coupler gasket **49** is seen just beginning to engage with the sealing surface **73** of the right end coupler.

In FIG. **5**C, the two PV panel assemblies have been urged further toward one another such that the locking tab **64** of the left end coupler has moved just beyond the locking tab **71** of the right end coupler. At this point, the locking tab **64** of the left end coupler drops downwardly until its end is in a confronting relationship with the end of the locking tab **71** of the right end coupler, as shown at **92** in FIG. **5**C. As this occurs, the left end coupler likewise drops down so that the fin **89** of the gasket **45** becomes compressed against the bottom of the vertical leg to form a seal against water penetration. At the same time, gasket **49** is compressed against the sealing surface **91** of the right end coupler to form a seal against water penetration along this interface. FIG. **6** is perspective view of two PV panel assemblies coupled together in an end-to-end relationship as just described and illustrates perhaps better the relationships of the various components of the couplers and their relationships to one another.

The sensation to an installer when installing PV panel assemblies end-to-end in a course is that when the end of one panel is urged into engagement with the end of an adjacent panel, a satisfying click-lock occurs. This tells the installer that a proper coupling together and sealing of the panels along their ends has been obtained. Each PV panel assembly is attached with screws to the roof deck as illustrated above when it has been properly installed in end-to-end relationship with a like PV panel assembly, thus progressively forming a course of PV panel assemblies.

When forming a course of PV panel assemblies above a previously installed course, an installer first slides an initial PV panel assembly down into a front-edge-to-back-edge engagement with panels of the previously installed course as described above. Preferably, but not necessarily, the initial panel is staggered relative panels in the previously installed course so that their end seams do not align. When the initial PV panel assembly is urged against the lower course, the installer again receives a satisfying click-lock confirmation that the couplers have fully engaged. This panel is then secured to the roof deck. The next PV panel assembly is slid down adjacent to the first and, once locked front-edge-to-back-edge with panels of the course below, is slid sideways into engagement with the just installed PV panel assembly. This locks the two panels both to the panels of the course below and in an end-to-end relationship with each other. Successive courses of PV panel assemblies are installed in this way until the PV array is complete.

As the PV panel assemblies are installed the outputs of their micro-inverters are connected electrically to those of previously installed PV panel assemblies of the array. Some possible connections are illustrated in FIG. **7**, where several PV panel assemblies **26** are shown in an array. As a step in the installation of a PV panel assembly in end-to-end relationship with a like PV panel assembly, the male elect al connector on the right end of one of the panel assemblies is connected to the female electrical connector on the left end of the other one of the panel assemblies. This connects the outputs of the micro-inverters of the two panel assemblies electrically in parallel. As the micro-inverter outputs of successive PV panel assemblies are added, the power rating of the installation is progressively increased.

For connecting the PV panel assemblies of one course to the PV panel assemblies of an adjacent course, one of two adapter cables may be used a male-to-male adapter cable **111** or a female-to-female adapter cable **112**. Male-to-male adapter cables are cables with a male electrical connector on each end and, similarly, female-to-female adapter cables are cables with a female electrical connector on each end. As can be seen in FIG. **7**, male-to-male adapter cables are used to connect courses of PV panel assembles together on the left side of an array of panels because the left end PV panel assemblies of each course has a female electrical connector **57**. Conversely, female-to-female adapter cables are used to connect one course of PV panel assemblies to an adjacent course on the right side of the array, where the end panels of adjacent courses each have male electrical connectors **56**. The PV panel assemblies are electrically connected sequentially as they are installed such that all electrical connections are completed at the end of the array installation and the full power rating of the array is established.

FIG. **8** illustrates perhaps better the cable management aspects of the PV panel assembly of this embodiment. Here, the underside of a portion of a PV array is illustrated and shows a first PV panel assembly **1**, a second PV panel assembly **2**, a third PV panel assembly **3**, and a forth PV panel assembly **4** interconnected as described above. Micro-inverters **51** are attached to the bottoms of the PV panel assemblies and support ribs **47** span the lengths of the panels and also form cable trays beneath each panel. The AC output of each micro-inverter **51** is connected via a junction **53** to a power cable **54**. The junction **53** is held in place to the bottom side of each assembly by clips **25** that are formed on the support rib **47**. The power cable **54** extends within the cable tray from one end of each PV panel assembly to the other and terminates at one end in a male electrical connector **56** and at the other in a female electrical connector **57**.

Each end of each power cable projects a sufficient distance from the ends of its PV panel assembly to allow two PV panel assemblies to be connected together electrically as they are installed on a roof deck in an end-to-end relationship. This is illustrated at the junction of PV panel assemblies **1** and **4** in FIG. **8**. To connect the PV panel assemblies of one course of PV panel assemblies to those of an adjacent course, adapter cables are used as mentioned above. FIG. **8** illustrates two alternative connections of this type. To connect the course of PV panel assemblies in which PV panel assembly **1** resides to a next higher course in which PV panel assembly **2** resides, adapter cable **93** is used. Adapter cable **93** terminates at each of its ends in a male electrical connector **56** and these male connectors connect to the female electrical connectors **57** at the ends of PV panel assemblies **1** and **2**. This connects the two courses of PV panel assemblies together electrically.

Alternatively, an adapter cable **94** can be used in the same way to connect PV panel assembly **3** of a next lower course of PV panel assemblies to the course of PV panel assemblies in which PV panel assembly **1** resides. The connections proceed in a sinuous manner from course to course at opposite edges of an installed array of PV panel assemblies so that the AC outputs of all of the PV panel assemblies of the array is aggregated to be directed to the public electrical grid or otherwise used. As illustrated in FIG. **8**, the cable tray and its various clips **48**, **53**, etc. as well as clips such as clips **30** and **41** at the edges of the PV panel assembly retain the cables and the connectors beneath the PV panel assemblies and above a roof deck below. This prevents direct contact between the electrical components and the roof deck, which in turn prevents potential chafing and damage to these components.

When installing an array of PV panel assemblies in courses, an initial or lowermost course must be installed along a lower part of a roof deck first, to which higher courses are installed as detailed above. FIGS. **9** and **10** illustrate in side and perspective views respectively a preferred structure for installation of the lowermost course of PV panel assemblies. More specifically, a starter strip coupler **101** is first installed along the roof. The starter strip coupler **101** is configured on its upslope side to form a shape that is essentially the same as the shape of the projection **97** (FIG. **4**B) of the back edge connectors **42**. It defines a slot **102** sized to receive the tongue **78** of front edge couplers **41** of PV panel assemblies and a ramp **105**. The front edge of the starter strip coupler **101** is simply flat rather than being configured for attachment to the back edge of a PV panel assembly. This forms an aesthetically pleasing nosing for the array of PV panel assemblies. A groove in an upper surface of the starter strip coupler carries a gasket **106**.

As with front-edge-to-back-edge couplings of PV panel assemblies in adjacent courses, the lowermost course of PV panel assemblies is formed by sliding PV panel assemblies down the roof deck and urging them into engagement with the starter strip coupler **101**. This causes the tongues **78** of the front edge couplers to move upwardly as they ride up the ramp **105** and then downwardly as the engage within the slot **102** of the starter strip coupler, as indicated by arrow **103**. This, in turn, causes the front edge **36** of the PV panel assembly to move up and then down as indicated by arrow **104** in FIG. **9**. As a result, the underside of the front edge of the PV panel assembly comes to rest on and compresses the gasket **106** forming a seal against water penetration along the front edge of the PV panel assembly.

Once a first PV panel assembly of the lowermost course in installed and attached to the roof deck via screws through its back edge couplers, a next adjacent PV panel assembly of the initial course can be installed. This is accomplished by sliding the next adjacent PV panel assembly downwardly to engage with the starter strip coupler **101** and then sliding the PV panel assembly sideways to urge its end into engagement with the end of the already installed PV panel assembly. This causes the ends of the PV panel assemblies to lock and seal as described above. Each PV panel assembly of the lowermost course is installed sequentially in this way until the lowermost course of PV panel assemblies is complete.

When installation of an array of PV panel assemblies is complete, the array likely will have left and right edges that are not straight and aligned and may instead define gaps. This is because the courses of the array may have offset panels at their ends and some courses may have fewer PV panel assemblies than others. In these instances, it may be desirable to fill the gaps along the edges of an installed PV array with dummy panels that do not produce electricity but are made to mimic the appearance of the PV panel assemblies of the array. For instance, dummy panels **29** in FIG. **1** are seen to fill irregularly shaped gaps along the left and right edges of a PV array atop a roof so that the edges of the completed installation are parallel or somewhat parallel with the edge contours of the roof. FIGS. **11-13** illustrate such dummy panels and how they may be coupled to the ends of PV panel assemblies to fill gaps along the edges of the array. Six variations of dummy panels **121**, **122**, **123**, **124**, **125**, **126** and **127** are shown in FIG. **11**. Each variation has an upper surface **128** that is fabricated to mimic the look of an active PV panel assembly. This upper surface may be formed of a variety of materials including, for example black PVC foam. Front edge couplers **131** are installed beneath the front edges **129** of the dummy panels just as they are for the active PV panel assemblies. Similarly, back edge couplers may be attached along the back edges of the dummy panels. In this way, dummy panels may be installed in an array in the same way that active PV panel assemblies are installed.

An end coupler **132** is attached along one end of each dummy panel. For example, in FIG. **11**, the end couplers **132** are attached along the left ends of the dummy panels. In this way, the dummy panels can be coupled to a free right end of a PV panel assembly along the edge of a PV array. Variations of dummy panels with couplers along their right ends also are available for filling gaps along the left edge of an installed PV array on a roof. The right ends of the dummy panels in FIG. **11** may be provided with or configured to accept a variety of structures such as step flashing and counter flashing to provide flashing and/or water sealing. FIG. **12** shows a dummy panel **121** filling a gap along the right edge of an installed PV panel array. Its end coupler **132** is shown secured to the right end coupler of PV panel assembly **137** with its back edge being overlapped by solar panel **138** and its front edge overlapping PV panel assembly **139**. It can be seen that the dummy panel **121** fills a gap along the edge of the installation and mimics the look of an active photovoltaic panel so that the edge installation appears straight and neat. Step flashing **139** interleaves with adjacent roofing shingles in the traditional manner and counter flashing **140** drapes over the step flashing. This provides a reliable barrier against migration of rainwater beneath the dummy panel and the array.

FIG. **13** shows one embodiment of a dummy panel left end coupler **132** and how it couples to a right end coupler **38** of an active PV panel assembly. The dummy panel end coupler **132** may be made of a resilient material such as extruded plastic or extruded or rolled aluminum and has a vertical leg **141** that attaches to and extends along the left end of a dummy panel **121**. A horizontal leg **142** projects from the top of the vertical leg **141** and terminates in a rolled-under edge **146**. A flange **143** projects downwardly and rearwardly from the rolled-under edge **146** and the flange **143** preferably can be flexed slightly due to the resiliency of the material from which the coupler is made. When installing a dummy panel to an end of an active PV panel assembly, the dummy panel is urged into engagement with the end of the PV panel assembly. This causes the flange **143** to flex as it rides up the ramp **72** of the right end coupler and to spring back to the position shown in FIG. **13** when the ramp **72** is cleared. Alternatively, the dummy panel can be pivoted in place at the junction between its coupler and the coupler of the PV panel assembly. In either event, the dummy panel is coupled in end-to-end relationship with the active PV panel assembly and compresses the gasket **144** to form a seal. When installed, dummy panels appear to be part of a PV array and fill unsightly gaps along the edges of the PV array to form the neat clean aligned edge shown in FIG. **1**.

Once the PV panel assembly array is installed with its dummy panels forming an aligned or otherwise neat edge along each side of the array, water barriers are required along the top edge of the array and along the left and right sides of the array. One way to accomplish this is through the use of flashing and counter flashing as illustrated in FIGS. **14-18**. In the illustrated embodiments, one flashing component comprises step flashing. Step flashing is well known in the roofing industry and generally means L-shaped flashing members **171**, preferably made of aluminum, that have one leg that is placed beneath the end of each course of adjacent roofing shingles and anther leg that extends up the side of the PV panel array. The step flashing members generally are installed progressively as roofing shingles are installed next to a PV array and, as they are installed; their second legs may be abutted against and/or secured to flanges **47** along the ends of the PV panel array. The step flashing members **171** of higher courses partially overlap step flashing members **171** of a next lower course. This forms a cascade effect and, along with the shingles with which the step flashing members are interleaved, prevents water from entering beneath the array at its ends.

When the step flashing members **171** are installed along the edges of a PV array, counter flashing is then preferably installed that overlaps the step flashing members **171** to enhance resistance to water penetration. Since the right ends of the PV panel assemblies and dummy panels bear right end couplers and their left ends bear left end couplers that are different from the right end couplers, unique right and left counter flashing members are used along respective edges of the installed array. FIG. **14** illustrates one embodiment of a counter flashing strip that can be used at the exposed right ends **33** of PV panel assemblies and dummy panels. As described above, these exposed right ends carry right end couplers **34** having locking tabs **71** and a gasket **45**. A counter flashing member **151**, which may be fabricated of aluminum or other appropriate material, is formed with a vertical leg **152** terminating along its bottom edge in an outwardly projecting foot **153**. The outwardly projecting foot is located to overly the previously installed step flashing members **161** and roofing shingles below. A horizontal leg **156** projects inwardly from the upper edge of the vertical leg **152** and terminates at a rolled-under edge **157**. A flange **158** depends from beneath the horizontal leg **156** and carries an upturned locking tab **159** at its lower end.

The counter flashing member **151** can be installed on a right end coupler **34** as shown with the locking tab **159** of the counter flashing, ember lodged beneath the locking tab **71** of the right end coupler. This compresses the gasket **45** as shown and for water seal along the rolled-under edge **157** of the counter flashing member. Preferably, gasket **49** is positioned to bear against the step flashing members **161** as well, thereby enhancing a seal along the step flashing members and the right end of the PV array. When a counter flashing member or members is installed on the exposed right end of a PV panel array overlapped with previously installed step flashing, the counter flashing and step flashing forms a barrier that prevents rainwater from entering beneath the PV panel array. Because of its effectiveness, step flashing and counter flashing are commonly used along the intersection of a wall or chimney and the shingled deck of a roof.

FIGS. **15** and **16** illustrate one embodiment of counter flashing for use along the left edge of an installed PV array. Here, step flashing members **171** are shown previously installed along the edge of the array and positioned by the flashing support flanges **47**. While not shown, it will be understood that the step flashing members are each disposed beneath the end shingle of a course of roofing shingles adjacent the PV array. The counter flashing members **172** may then be installed on the exposed left ends of each PV panel assembly and dummy panel in such a way that they drape over the vertical legs of the step flashing members **171**. The end of each PV panel assembly along an edge of the PV array receives a corresponding counter flashing member **172** with the counter flashing members of lower courses being overlapped slightly with those of upper courses. As perhaps best illustrated in FIG. **16**, the left edge counter flashing strips **172** are formed with a vertical outer wall **177** that terminates at its upper extent in a rolled edge **178**. A vertical inner wall **180** projects downwardly from the rolled edge and is spaced from the outer wall **177** to define a vertical slot **185**. The counter flashing member **172** is further formed to define an internal trough **181** inboard of the vertical inner wall **180**. An angled locking tab **179** is configured to wedge behind the locking tab **64** of the left end coupler **39** to hold the counter flashing member **172** in place. When installed, the slot **185** may at least partially receive the vertical legs of the previously installed step flashing members **171** as shown in FIG. **16**.

The counter flashing strip **172** connects to the left end coupler **39** of a corresponding PV panel assembly and is locked in place by the locking tab **179**. At the same time, the gasket **49** is compressed against the inner wall of the trough **181** as shown to form a moisture seal at this location. Water that may leak beneath the left end coupler **39** and the counter flashing member **172** falls into the trough **181** and is directed downwardly to the lower end of the array where it can be safely expelled. Further the counter flashing members extend downwardly to overlie and cover the previously installed step flashing members **171** thus forming a water shed that insures against windblown rain seeping behind the step flashing members and onto a bare roof deck below.

FIGS. **17** and **18** illustrate one possible structure for flashing along the top edge and at the top corners of an installed PV array according to one embodiment. In FIG. **17**, the back edge **191** of an installed PV array is shown with its back edge coupler **42** being fastened to a roof deck **50** with screws **80** or other appropriate fasteners. A lowermost course of shingles **192** extends along and is spaced from the back edge of the array. A flashing strip **193** extends from beneath the lowermost course of shingles **192** away from the roof deck and rests atop the PV panel assemblies along the back edge of the array. The flashing strip **193** may be attached to the deck **50** beneath the roofing shingles with roofing nails or other appropriate fasteners. Likewise, the flashing strip may be attached to the seal strip **43** with screws, adhesive, or other fasteners so that the flashing strip compresses the gasket **44** of the seal strip **43** forming a seal against windblown rain. Rainwater that is shed down the roof shingles **192** is directed by the flashing strip **193** to the upper surfaces of the PV panel assemblies of the top course. From there, the rainwater cascades down the faces of the PV panel assemblies of the array without leaking at the vertical or the horizontal joints of the PV panel assemblies because of the sealed interfaces described above.

As shown in FIG. **18**, the top corners of the installed PV array may be covered with a molded or formed corner cap **194** that covers the ends of the top flashing strip **193**. The corner cap **194** also covers the upper ends of step flashing and counter flashing members along the ends of the uppermost PV panel assemblies. In this way, water is prevented from seeping beneath the assembly at the top corners thereof.

FIGS. **19-29** illustrate an alternate embodiment of the invention that is modified somewhat in its details from the just described embodiment and includes additional novel features. However, many other details of this alternate embodiment are not significantly different from those of the previously described embodiment. Where this is the case, such details will not be described in depth a second time in the discussion of the alternate embodiment that follows.

FIG. **19** shows a PV panel assembly **201** that incorporates a commercially available solar panel **204** (shown transparent in FIG. **19** for clarity) having a peripheral frame. A left end coupler **202** is attached along the left end of the PV panel and a right end coupler **203** is attached along the right end of the panel. Five spaced apart top edge couplers **206** are attached along the top edge of the PV panel and a pair of bottom edge couplers **207** is attached in spaced relationship along the bottom edge of the PV panel. A cable tray **208** is attached beneath the PV panel and is configured to support and facilitate management of the various electrical cables of the assembly. More specifically, in this embodiment, the cable tray **208** comprises a left panel **209** and a right panel **211**. The left and right panels extend from the top edge to the bottom edge of the PV panel. A relatively narrow central panel **212** spans the left and right panels and all of the panels are perforated to reduce amount of material used, to reduce weight of the assembly, and to promote ventilation beneath the assembly. Unlike the prior embodiment, the cable tray of this embodiment does not rest on a roof deck to provide support for the PV panel assembly, but rather serves merely as a cable management feature and to keep the various cables of the assembly raised above a roof deck.

A micro-inverter **213** is mounted beneath the solar panel **204** and receives DC input from the solar panel via input cables **223**. AC output from the micro-inverter is directed through output cable **222** to splitter **221** and onto main AC cable **214**. The main AC cable **214** is terminated at its left end with a female (or male) electrical connector and is terminated at its right end with a male (or female) electrical connector (not visible). The main AC cable **214** may be secured with clips **218** and **219** integrated into the PV panel assembly. Excess cable at the left and right ends of the main cable **214** is snaked up (or down) through a bend **217** that is supported on a respective one of the end panels **209** and **211**. The width of the end panels **209** and **211** is selected to accommodate the rather large minimum bend radius of the main AC cable **214**, which typically is rather thick. Significantly, the left and right ends of the main cable **214** can be reoriented if needed so that the electrical connector can extend upwardly as shown on the right in FIG. **19** or downwardly as shown on the left in FIG. **19**. To change the direction, an installer need only manipulate the end portion of the cable **214** so that it bends in the opposite direction atop the end panel of the cable tray. This may be necessary, for instance, when connecting one course of PV panel assemblies to a next higher or next lower course or in other instances.

FIG. **20** illustrates an installation or array **228** of PV panel assemblies **201** of FIG. **19** on a roof **227**. As with the prior embodiment, the PV panel assemblies are coupled together end-to-end and the courses of PV panel assemblies are coupled together top-to-bottom in manners described in more detail below. The panel assemblies **201** may be installed in an aligned array as shown in the top two courses of PV panel assemblies in FIG. **20**; in a staggered array as shown in the bottom two courses of FIG. **20**; or in other arrangements determined by a contractor. FIG. **20** also shows various flashing components for preventing migration of rainwater beneath the installation **228**. These include, for example, top flashing **229**, step flashing **231**, counter flashing **232**, inside corner flashing **233** among other flashing components. These flashing components will be described in more detail below. It will be noted that the installation of FIG. **20** does not include faux panels filling gaps at the ends of the installation. Such faux panels are described in more detail below and may be used by a contractor to fill gaps at the end-of a PV panel assembly installation and thereby provide a cleaner looking array on a roof.

FIG. **21** is a perspective end view showing two PV panel assemblies coupled together end-to-end and illustrates an alternate and enhanced embodiment of the left end and right end couplers that differs from those of the previously described embodiment. The left end coupler **238** is shown attached to the left end **236** of a first solar panel and the right end coupler **246** is attached to the right end **237** of a second solar panel. The couplers preferably are made of extruded aluminum, but other materials such as steel or plastic may be substituted to obtain similar results. The left end coupler **238** comprises a vertical leg **239** that is attached to the left end **236** with rivets or other appropriate fasteners (not visible). A horizontal leg **241** projects from the vertical leg **239** to a distal edge **240** located adjacent the right end **237** of the second solar panel. A ramp **242** projects at an angle downwardly and in inwardly beneath the distal edge **240**. The left end coupler **238** is further formed with a T-channel member **245** that extends inwardly from the vertical leg **239** and is configured to secure a compressible bulb gasket **243**. A groove adjacent and extending along the upper edge of the vertical wall **239** is shaped to receive a bead gasket **244**, which forms a seal between the left end coupler **238** and the left end **236** of the solar panel.

The right end coupler **246** is configured with a vertical leg **248** attached to the right end **237** of the second solar panel with rivets **250** or other appropriate fasteners. A bead gasket **249** is disposed in a groove extending along and adjacent the upper edge of the vertical leg and forms a seal against the vertical leg and the right end **237** of the solar panel. A horizontal leg **247** projects outwardly from the lower edge of the vertical leg to an edge. A support leg **252** extends upwardly from the horizontal leg **247** intermediate its ends and supports an angled ramp surface **253** and an upstanding tab **254** along the distal end of the ramp surface **253**. A fin or wiper gasket **251** is secured in a T-slot formed with and extending along the vertical leg **248** of the right end coupler **246** and extends upwardly at an angle therefrom. In FIG. **21**, the left and right end couplers are shown coupled together joining and sealing between the two PV panel assemblies. More specifically, the bulb gasket **243** of the left end coupler is shown compressed against the upper surface of the horizontal leg **247** of the right end coupler forming a seal at that location. The wiper gasket **251** is seen to be bent and bearing against the ramp **242** thereby forming a seal at that location.

During installation, two PV panel assemblies are coupled together end-to-end with the left and right end couplers in a manner similar to that used for the end couplers of the previous embodiment. More specifically, the left and right ends of two PV panel assemblies are urged together by an installer. As the ends draw nearer, the ramp **242** first engages and begins to ride up the tab **254** raising the left end **236** of the first panel relative to the right end **237** of the second panel. The tab **254** may thus be thought of as a ramp follower. At some point, the ramp **242** clears the tab **254** and drops down to engage the angled ramp surface **253** thereby providing a confirming 'click' sound and feel to the installer. The edge of the ramp **242** then rides progressively down the angled extension leg to the position shown in FIG. **21**. This, in turn, brings the bulb gasket **243** progressively into engagement with the vertical leg **247** of the right end coupler **246** and progressively moves the ramp **242** into compressive or bending engagement with the wiper gasket **251**. Seals are thus formed at the locations of the bulb gasket **243** and the fin gasket **251** against migration of rainwater through the junction of the two PV panel assemblies. Even if a perfect seal is not formed by the fin gasket **251**, any water that breaches the seal will simply fall into the channel below to be shed downwardly to the bottom edges of the panel assemblies from where it can cascade down the array.

FIG. **22** illustrates alternate embodiments of the top and bottom edge couplers for coupling panels together in a top-to-bottom relationship that include additional and novel features. As with the prior embodiment, a plurality of top edge couplers are attached in spaced relationship (see FIG. **19**) along the top edge of each panel assembly. Similarly, a pair of spaced apart bottom edge couplers **264** is attached along the bottom edge of each panel assembly. Each top edge coupler **263** comprises a rearwardly extending base **266** and a sloped ramp **267**. Unlike the prior embodiment, the top edge connectors of this embodiment are further formed to define a V-shaped ground wire channel **268** with grounding screw **269** that threads into the ground wire channel. The back edge coupler **263** is formed with a U-shaped portion **272** that defines a cable race to aid in routing cables of the system beneath a panel installation and may be fastened to an underlying roof deck with screws **277**.

Each bottom edge coupler **264** attaches with appropriate fasteners such as rivets **270** to the bottom edge of a solar panel and extends downwardly therefrom. The lower extent of each bottom edge coupler **264** is configured to define a tongue **271** with the illustrated shape, which is somewhat different than the configuration of the tongue in the previous embodiment. A separate top edge extrusion **259** is attached with appropriate fasteners to the extreme top edge of the PV panel assembly and extends the entire length thereof. The top edge extrusion **259** carries an upwardly projecting wiper gasket **274** and a bead gasket **276**, and the bead gasket **276** compresses against and forms a seal along the extreme top edge of its solar panel. A bulb gasket **273** extends along the entire length of and depends from the bottom edge of each PV panel assembly.

Two PV panel assemblies are coupled together in a top-to-bottom relationship in substantially the same way as with the prior embodiment. That is, a lower course of PV panel assemblies are installed in end-to-end relationship on a roof deck as

described above by coupling them together end-to-end and screwing each assembly to the roof deck through its top edge couplers. In the present embodiment, a copper ground wire may then be inserted through the V-shaped ground wire channels **268** of the exposed top edge connectors **263** and the grounding screws **269** tightened onto the ground wire to make a secure electrical connection. This ground wire attaches to at least one top edge connector of each PV panel assembly of an installation and provides a separate and redundant system ground for the installation to enhance safety. AC power cables of the system can then be routed through selected ones of the cable races **272** of the exposed top edge couplers to help hold them in place for interconnecting courses of PV panel assemblies together electrically.

A PV panel assembly of a next higher course is then slid down the roof toward PV panel assemblies of the lower course with each bottom edge connector of the panel assembly aligned with a selected corresponding top edge connector of one or more PV panel assemblies of the lower course. The two bottom edge couplers of each PV panel assembly are space to align with corresponding ones of the five top edge couplers of the next lower course to form a variety of possible offsets between panels of adjacent courses. For example, panels in adjacent courses may be offset relative to each other by one quarter, one third, or one half the width of a panel assembly. As the panel assemblies are urged together top-to-bottom, the tongues **271** of the bottom edge couplers of the upper panel assembly ride up the ramps **267** of the top edge couplers of the lower panel assembly(s). This elevates the bottom edge of the upper panel assembly above the top edge of the lower panel assembly. The tongues **271** then crest the ramp **267** and slide down the other side to the position shown in FIG. **22**. This provides a confirming "click-lock" sound and feel to the installer. More importantly, however, it causes the bottom edge of the upper PV panel assembly to drop down into overlapping relationship with the top edge of the lower PV panel assembly. This motion, in turn, compresses the bulb gasket **273** between the two edges to form a primary seal. Simultaneously, the fin seal **274** is engaged and bent down between the bottom edge of the upper PV panel assembly and the top edge extrusion **259**. This forms a secondary seal between the two PV panel assemblies to provide further assurance against rainwater leakage between panels.

FIGS. **23***a* through **23***e* illustrate perhaps more clearly the separate extrusion profiles of each of the just described end and edge couplers. FIG. **23***a* shows the profile of a right end coupler **246** and FIG. **23***b* shows the profile of a left end coupler **238**. The separate back edge extrusion **259** is shown clearly in FIG. **23***c*. FIG. **23***d* illustrates the profile of the bottom edge couplers **264** while FIG. **23***e* shows the profile of the top edge couplers **263** with their V-shaped ground wire channels and cable races. Of course, variations of the profiles may well be imagined and implemented by the skilled artisan without departing from the invention embodied in these particular example profiles.

FIG. **24** illustrates alternate embodiments of some of the various flashing components used to prevent rainwater migration beneath a PV panel installation. In this figure, an upper right corner of an installation of vertically aligned PV panel assemblies **279**, **281** is shown. Top flashing **282** extends from beneath a course of shingles **280** above the installation to a position overlying the uppermost edge of the PV panel assembly installation. Unlike the prior embodiment, the top flashing of this alternate embodiment has an exposed front edge **283** that is formed with an array of louvers **284** forming a ventilation grid along the uppermost edge of the assembly. It has been found that substantial heat can be generated below a PV panel assembly installation. The ventilation grid formed by the array of louvers **284** promotes convective flow of this heated air beneath the installation for cooling. As an alternative, the heat developed beneath a PV panel assembly installation may be harvested with heat exchangers or other devices disposed beneath the assembly and harvested heat may be stored as, for example, hot water for use by a consumer.

Referring again to FIG. **24**, a straight corner flashing component or corner cap **286** is shown covering the upper right corner of the installation and is formed with a side skirt that forms a counter flashing extending down the edge of the straight corner flashing component. Also shown in FIG. **24** are step flashing components **287** installed in the traditional way beneath successive courses of shingles with the hidden vertical legs of the step flashing shown behind the counter flashing in phantom lines. A right end counter flashing component **288**, described in more detail below, is attached along the edges of the PV panel assemblies and each has an outside skirt that overlies the vertical legs of the step flashing components **287** thus forming counter flashing. Caps **289** may be snapped or otherwise installed in the ends of the counter flashing components **288** if desired. As with the prior embodiment, rainwater is shed up and over the PV panel assembly installation and is shed away from edges and corners of the installation. It has been found that properly installed flashing components substantially prevent rainwater from penetrating beneath a PV panel assembly installation. Any water that may seep beneath the assembly is shed down the roof and beneath the forward edge of the installation by an underlayment membrane beneath the installation.

FIG. **25** shows an array of various flashing and faux panel components of the system of this embodiment that may be formed or extruded from metal or other appropriate material. More specifically, component **291** is a top angled corner flashing component for flashing the top corner of a PV panel assembly installation that forms an angle rather than the straight corner shown at **286** in FIG. **24**. Component **292** have an outer edge **293** is an example of a faux panel for filling gaps at the ends of a PV panel assembly installation, as will be described in more detail below. Component **294** is a support rib for mounting to the bottom of a faux panel to support the panel on a roof deck. Component **296** is a right end counter flashing member such as that shown in FIG. **24** at **288**. Component **297** is a lower inside corner flashing member for flashing lower inside corners of an installation, as described in more detail below. Component **282** is a top flashing member having an elevated forward edge **283** and ventilation louvers **284**. Component **298** is a step flashing member and component **299** is an inside corner flashing member. Finally, component **301** is a left end counter flashing member for counter flashing the left-most edge of a PV panel or faux panel. The right end counter flashing **296** and the left end counter flashing **301** are formed with features that interlock with the right end and left end couplers **203** and **202** (FIGS. **19**, **21**, and **22**) at respective ends of PV panel assemblies to counter flash the edges of a PV panel assembly installation.

FIG. **26** shows a sequence of 11 frames (a-k) illustrating progressively the installation of numerous flashing components to flash a gap at an end of a PV panel assembly installation when faux panels are not to be used to fill the gap. In frame a, **304** is a right-most end PV panel assembly of an already installed lower course of PV panel assemblies and **303** is the right-most PV panel assembly of an upper course of PV panel assemblies. It can be seen that the PV panel assembly **304** extends further to the right than PV panel assembly **303** thereby defining a gap along the right-most edge of the installation. Another course of PV panel assemblies is to be installed above the course of which panel assembly **303** is a member, and it too will extend further to the right to define the upper edge of the gap. A first step in the installation method is to install a length of top flashing **282** along the top edge of the PV panel assembly **304**. Next (frame b) an AC cable adapter **307** is routed from panel **303** and positioned to be electrically connected to the AC cable of the next higher course of PV panel assemblies. When this cable adapter has been connected and positioned, a lower inside corner flashing member **308** (frame c) is attached at the lower inside corner of the gap covering the end of the top flashing **282** and extending up the end of panel assembly **303**.

In frame d, a length of step flashing **298** is laid atop the upper portion of the lower inside corner flashing **308** and in frame e, a course of shingles **309** is installed against the panel **303** covering the step flashing **298** and the upper edge of the top flashing **282**. In frame f, another piece of step flashing **298** is installed against the PV panel assembly **303** overlying the headlap portion of shingle **309** as is typical when installing step flashing during a roofing installation. In frame g, another course of shingles **110** is installed against the PV panel assembly **303** overlying the step flashing **298** and an additional course of shingles **111** is installed above the course **110** to extend beneath the next higher course of PV panel assemblies. The AC cable is routed atop this course of shingles.

Next, in frame h, an upper inside corner flashing **299** is installed at the top corner of PV panel assembly **303** overlying the shingles. In frame i, a starter bar **312** is installed on the shingles covering the top flap of the upper inside corner flashing **299** and oriented coextensively with the top edge of PV panel assembly **303**. This starter bar will provide support for a PV panel assembly of the next higher course that extends beyond the right end of panel assembly **303**. In frame j, right end counter flashing **296** is fastened to the right end coupler of the PV panel assembly **303** and extends downwardly over the vertical legs of the step flashing and corner flashings to provide counter flashing along the end of the panel **303**. Finally, in frame k, a PV panel assembly **306** of the next higher course is installed so that the front edge of this assembly is partially supported atop PV panel assembly **303** and the other portion is supported atop the starter bar **312**. The gap is thus fully flashed and waterproofed.

It is believed that contractors and installers may wish to fill gaps along ends of PV panel assembly installations with faux panels as detailed below so that the just described installation method to flash gaps will not be required. Nevertheless, the invention includes these flashing components and this flashing technique, in the event faux panels are not to be used.

FIG. **27** illustrates the use of faux panels to fill gaps along ends of PV panel assembly installations to provide a more pleasing appearance along the ends of the installations. Faux panels are non-functioning panels that are colored to look like and blend in with the functioning PV panel assemblies. In the illustrated embodiment, a limited selection of faux panel shapes are provided that will suit the great majority of requirements to straighten out ends of PV panel installations that extend at three common roof angles. These three angles correspond to the three most common valley angles on roofs. Faux panels to fill gaps along straight end installations also are provided. The selected faux panel configurations are illustrated at the top of FIG. **27** and it will be seen that there is a right up and right down and a left up and left down version of each of the three configurations, in addition to rectangular faux panels. More specifically, there is a right up quarter panel **316**, a right up third panel **317** and a right up half panel **318**. Terminology like "right up quarter" refers, for example, to the fact that a panel so designated is for the right end of a PV panel assembly installation where the angle extends up the roof and the upper edge of the faux panel is a quarter of the length of a full PV panel assembly.

With continuing reference to the upper images of FIG. **27**, further selected configurations of faux panels include left up quarter panels **323**, left up third panels **324**, and left up half panels **325**. In a similar way, the selected faux panel configurations include left down quarter panels **319**, left down third panels **321**, and left down half panels **322**. Corresponding right down quarter panels **326**, right down third panels **327**, and right down half panels **328** are also included in the selected configurations. The selected configurations finally include rectangular faux panels including a rectangular third panel **329**, a rectangular quarter panel **331**, (not shown) a rectangular half panel and a rectangular full panel.

Images a through l in FIG. **27** illustrate various configurations of PV panel assembly installations that can be obtained using the selected configurations of faux panels discussed above. In these figures, roof valleys of various angles are illustrated by reference numeral **341**. Image a illustrates a quarter offset pattern installation wherein the panel assemblies of one course of PV panel assemblies are offset by a quarter of the length of a panel assembly from panel assemblies of adjacent courses. This example shows an installation with one straight end on the left and one angled end on the right adjacent the roof valley **341**. Along the right end, gaps are filled with right down quarter panels **326** and the gaps along the left side are filled with rectangular quarter faux panels **331**. Image b shows a parallelogram installation with two angled ends installed between two roof valleys **341**. Again, the PV panel assemblies of the installation are offset by a quarter of a panel and the resulting gaps on the right are filled with right down quarter panels **326** while the gaps along the left end are filled with left up quarter panels **323**.

Image c shows a trapezoid PV panel assembly installation where the installation is disposed between two downwardly extending roof valleys **341**. Again, the PV panel assemblies are offset by a quarter panel and the resulting gaps along the right end are filled with right down quarter panels **326** as before. Two rectangular quarter panels **331** (or one rectangular half panel) fills the excess gap along the middle course of PV panel assemblies to even the gaps and left down quarter faux panels **319** fill the remaining gaps to provide a straight left end. Image d shows an installation where the PV panel assemblies of each course are offset by one third the length of an assembly relative to each other. Resulting gaps on the right are filled with rectangular third faux panels **329** and resulting gaps on the left are filled with left down third faux panels to result in a neat straight end for the installation.

Image e shows a parallelogram installation with PV panel assemblies offset by one third the length of a panel assembly. Here, the angled right end gaps are filled with right down third faux panels and the gaps on the left end are filled with left down third faux panels. Image f shows a trapezoidal installation with PV panels offset by a third the length of a panel. Here, the gaps along the right end of the installation are filled with right down third faux panels. On the left, excess gap width is filled with rectangular third faux panels and remaining gaps are filled with left down third faux panels. Images g through l show the same three examples except with the PV panel assemblies of each course being offset by half the width of a panel assembly to produce even more acute angles along the ends of the installation. In image g, the left end gaps are filled with left up half faux panels and the excess gap on the straight right side is filled with two rectangular quarter panels (or one rectangular half panel). Image h shows the parallelogram installation with PV panel assemblies offset by half the length of an assembly. Here, the right end gaps are filled with right up half faux panels while the left end gaps are filled with left down half faux panels.

Image i shows a PV panel assembly installation between two roof valleys of different angles and illustrates the diversity of the faux panel system of the invention. Again, the PV panel assemblies are offset by half. Along the left end of the installation, gaps are filled with left up half faux panels. However, on the right edge, excess gap portions are filled with rectangular panels and the remaining gaps are filled with right down quarter faux panels to form an end with a different angle than that of the left end. Images j and k show two possible configurations that obtain rectangular installations of PV panel assemblies, the left image being a running bond brick pattern with the right being a stacked bond pattern. Finally, image l shows an installation of PV panel assemblies where no faux panels are used and gaps are left unfilled. As mentioned above, such an installation requires rather complex flashing to seal it against migration of rainwater.

FIGS. **28***a* and **28***b* show in more detail the construction of the faux panels of the present embodiment. FIG. **28***a* shows the faux panel with its metal panel portion opaque to match the appearance of adjacent PV panel assemblies. FIG. **28***b* shows the same faux panel with its panel portion rendered as transparent in the drawing to reveal structures beneath the faux panel. The faux panel **340** has a panel portion made of formed metal or other appropriate material that has a top portion **338** painted or otherwise treated to resemble a PV panel assembly. The faux panel **340** is bent to define a bottom edge portion **338** and also is bent along its angled side to form an integrated counter flashing **329**. A right end coupler **248**, which is the same as the right end couplers of PV panel assemblies, is attached with rivets or other fasteners long the right end of the faux panel. Similarly, a top edge coupler extrusion **259** is attached to and extends along the top edge of the faux panel and bears fin gasket **274** as shown in detail in FIG. **22**. A bottom edge coupler **264** is attached to the bottom edge **338** of the faux panel and a bulb gasket **273** extends beneath the bottom edge. Referring to FIG. **28***b*, a set of support ribs **331**, **332**, **333**, and **334** of appropriate lengths are attached beneath the top panel **338** and are sized and configured to rest atop a roof deck on which the faux panels are installed to provide structure and support for the faux panels.

When installing a faux panel such as panel **340**, it is coupled to adjacent PV panel assemblies in the same way that these panel assemblies are coupled to each other. This is because the faux panels **340** bear the same end and edge couplers as the functioning PV panel assemblies. Since the angled end of a faux panel always extends along the end of an entire PV panel assembly installation, step flashing can be installed along this end simply by sliding step flashing components beneath the integral counter flashing **329** of the faux panel with shingle courses overlapping the step flashing as is customary in shingle installation. FIG. **29** shows various faux panel configurations from the undersides thereof to illustrate one preferred placement and sizing of the support ribs beneath the faux panels. Other configurations and positioning may be used, of course, and the illustrated ones are exemplary only. Each faux panel has at least one support rib that is formed with a top tab extending beyond the top edge of the faux panel. This provides a fastening tab for the faux panels, which are fastened to a roof deck with screws or other fasteners driven through the fastening tabs.

The invention has been described herein within the context and in terms of preferred embodiments and methodologies that represent the best modes known to the inventors of carrying out the invention. However, the embodiments presented above and in the drawing figures are not intended to represent requirements or limitations of the invention that they embody, but are presented only as exemplary embodiments of the underlying invention. Many additions, deletions, and modifications, both subtle and gross, may be made to the embodiments of the invention presented herein without departing from the spirit and scope of the invention embodied in the particular embodiments and defined by the claims hereof.

What is claimed is:

1. A photovoltaic element for joining with like photovoltaic elements on a roof to form a roof integrated photovoltaic system, the photovoltaic element comprising:

a photovoltaic panel having a right end, a left end, a front edge, and a back edge;

a right end coupler secured to the right end of the photovoltaic panel;

a left end coupler secured to the left end of the photovoltaic panel;

the right end coupler and the left end coupler being configured so that when the photovoltaic element is slid on the roof into end-to-end engagement with a like photovoltaic element on the roof, the right and left end couplers interlock and form a seal in response to being slid into end-to-end engagement;

at least one front edge coupler affixed to the front edge of the photovoltaic panel;

at least one back edge coupler affixed to the back edge of the photovoltaic panel;

the front edge coupler and the back edge coupler being configured so that when the photovoltaic element is slid on a roof into top-edge-to-bottom-edge engagement with a like photovoltaic element on the roof, the front and back edge couplers of the photovoltaic elements interlock in response to being slid into top-edge-to-bottom-edge engagement.

2. A photovoltaic element as claimed in claim **1** wherein the front edge coupler and the back edge coupler are further configured so that the front edge of the photovoltaic element is elevated above the back edge of a like photovoltaic element and then drops onto the back edge of the like photovoltaic element in response to being slid on the roof into top-edge-to-bottom-edge engagement with the like photovoltaic element.

3. A photovoltaic element as claimed in claim **2** further comprising a seal positioned on the photovoltaic element and configured so that the seal becomes compressed between the front edge of the photovoltaic element and the back edge of a like photovoltaic element when the front edge of the photovoltaic element drops onto the back edge of the like photovoltaic element.

4. A photovoltaic element as claimed in claim **1** further comprising a seal on at least one of the right end coupler and the left end coupler, the seal being configured and positioned to be compressed when the left and right end couplers interlock to seal a junction between the left end coupler and the right end coupler.

5. A photovoltaic element as claimed in claim **1** further comprising a cable tray beneath the photovoltaic panel for supporting cables associated with the photovoltaic element.

6. A roof integrated photovoltaic system comprising:

a plurality of adjacent photovoltaic panels each having a right end, a left end, a front edge, and a back edge;

a right end coupler secured to the right ends of at least some of the photovoltaic panels;

a left end coupler secured to the left ends of at least some of the photovoltaic panels;

the right end couplers and the left end couplers configured to interlock and form a seal when two of the plurality of panels are moved into end-to-end engagement;

at least one front edge coupler affixed to at least some of the plurality of photovoltaic panels at the front edges thereof;

at least one back edge coupler affixed to at least some of the plurality of photovoltaic panels at the back edges thereof;

the front edge couplers and the back edge couplers configured to interlock when two of the plurality of panels are moved into top-edge-to-bottom-edge engagement;

a seal positioned to prevent water from penetrating at the junction of a front edge of one panel and the back edge of an adjacent interlocked panel;

each photovoltaic panel producing a voltage at output terminals when the photovoltaic panel is exposed to sunlight;

a cable having ends and being disposed beneath each photovoltaic panel, the output terminals being electrically coupled to the cable with at least one of the ends of the cable being electrically coupled to the end of a cable of an adjacent photovoltaic panel of the system to aggregate the electrical energy of the plurality of photovoltaic panels; and

a cable tray disposed beneath at least some of the photovoltaic panels, cables of the photovoltaic panels being at least partially supported by the cable trays.

7. A roof integrated photovoltaic system comprising:

a plurality of adjacent photovoltaic panels each having a right end, a left end, a front edge, and a back edge;

a right end coupler secured to the right ends of at least some of the photovoltaic panels;

a left end coupler secured to the left ends of at least some of the photovoltaic panels;

the right end couplers and the left end couplers configured to interlock and form a seal when two of the plurality of panels are moved into end-to-end engagement;

at least one front edge coupler affixed to at least some of the plurality of photovoltaic panels at the front edges thereof;

at least one back edge coupler affixed to at least some of the plurality of photovoltaic panels at the back edges thereof;

the front edge couplers and the back edge couplers configured to interlock when two of the plurality of panels are moved into top-edge-to-bottom-edge engagement;

a seal positioned to prevent water from penetrating at the junction of a front edge of one panel and the back edge of an adjacent interlocked panel;

each photovoltaic panel producing a voltage at output terminals when the photovoltaic panel is exposed to sunlight;

a cable having ends and being disposed beneath each photovoltaic panel, the output terminals being electrically coupled to the cable with at least one of the ends of the cable being electrically coupled to the end of a cable of an adjacent photovoltaic panel of the system to aggregate the electrical energy of the plurality of photovoltaic panels; and

wherein the back edge couplers are configured to define a cable race, the cables of the photovoltaic panels being at least partially supported in the cable race of at least one back edge coupler.

8. A roof integrated photovoltaic system comprising:

a plurality of adjacent photovoltaic panels each having a right end, a left end, a front edge, and a back edge;

a right end coupler secured to the right ends of at least some of the photovoltaic panels;

a left end coupler secured to the left ends of at least some of the photovoltaic panels;

the right end couplers and the left end couplers being configured to interlock and form a seal when two of the plurality of panels are moved into end-to-end engagement;

at least one front edge coupler affixed to at least some of the plurality of photovoltaic panels at the front edges thereof;

at least one back edge coupler affixed to at least some of the plurality of photovoltaic panels at the back edges thereof;

the front edge couplers and the back edge couplers configured to interlock when two of the plurality of panels are moved into top-edge-to-bottom-edge engagement;

a seal positioned to prevent water from penetrating at the junction of a front edge of one panel and the back edge of an adjacent interlocked panel;

the left end and right end couplers being profiled such that one of the couplers is elevated relative to the other coupler and then drops onto the other coupler into locking relationship as two like photovoltaic panels are urged together end-to-end; and

at least one gasket extending along the left end coupler or the right end coupler and being positioned to be compressed between the couplers when the one coupler drops onto the other coupler to form a water inhibiting seal.

9. A roof integrated photovoltaic system comprising:

a plurality of adjacent photovoltaic panels each having a right end, a left end, a front edge, and a back edge;

a right end coupler secured to the right ends of at least some of the photovoltaic panels;

a left end coupler secured to the left ends of at least some of the photovoltaic panels;

the right end couplers and the left end couplers configured to interlock and form a seal when two of the plurality of panels are slid on a roof into end-to-end engagement;

at least one front edge coupler affixed to at least some of the plurality of photovoltaic panels at the front edges thereof;

at least one back edge coupler affixed to at least some of the plurality of photovoltaic panels at the back edges thereof;

the front edge couplers and the back edge couplers configured to interlock when two of the plurality of panels are slid on a roof into top-edge-to-bottom-edge engagement;

a seal positioned to prevent water from penetrating at the junction of a front edge of one panel and the back edge of an adjacent interlocked panel;

the front and back edge couplers being profiled such that the front edge of a photovoltaic panel is elevated above the back edge of a like panel and then drops down onto the back edge of the like panel in response to the two photovoltaic panels being slid together front edge to back edge on a roof.

10. A photovoltaic panel assembly for installation on a deck with like photovoltaic panel assemblies to form a photovoltaic array for converting sunlight to electrical energy, the photovoltaic panel assembly comprising:

a solar panel having a peripheral frame surrounding a solar collector that produces DC voltage when exposed to sunlight, the solar panel having left and right ends and front and back edges;

a left end coupler extending along the left end of the solar panel;

a right end coupler extending along the right end of the solar panel;

at least one front edge coupler secured at the front edge of the solar panel;

at least one back edge coupler secured at the back edge of the solar panel;

the left and right end couplers being configured to lock into sealing engagement when the ends of two like panels are urged together in an end-to-end relationship;

the at least one front edge coupler and the at least one back edge coupler being configured to lock into engagement when the bottom edge of the photovoltaic panel assembly is urged toward the top edge of a like photovoltaic panel assembly; and

electrical wiring beneath the photovoltaic panel assembly for coupling the electrical energy produced by the panel assembly with electrical energy produced by like panel assemblies in an array;

one of the left and right end couplers comprising a ramp and the other one of the left and right couplers comprising a ramp follower, the ramp and ramp follower being configured to engage one another as the ends of two like photovoltaic panel assemblies are urged together to elevate the end coupler of one of the photovoltaic panel assemblies and then to allow the elevated end coupler to drop onto the end coupler of the other one of the photovoltaic panel assemblies.

11. The photovoltaic panel assembly of claim **10** further comprising at least one gasket on one of the end couplers, the gasket being positioned to be compressed between the end couplers when the elevated end of the one photovoltaic panel assembly drops onto the end coupler of the other one of the photovoltaic panels.

12. A photovoltaic panel assembly for installation on a deck with like photovoltaic panel assemblies to form a photovoltaic array for converting sunlight to electrical energy, the photovoltaic panel assembly comprising:

a solar panel having a peripheral frame surrounding a solar collector that produces DC voltage when exposed to sunlight, the solar panel having left and right ends and front and back edges;

a left end coupler extending along the left end of the solar panel;

a right end coupler extending along the right end of the solar panel;

at least one front edge coupler secured at the front edge of the solar panel;

at least one back edge coupler secured at the back edge of the solar panel;

the left and right end couplers being configured to lock into sealing engagement when the ends of two like panels are urged together in an end-to-end relationship;

the at least one front edge coupler and the at least one back edge coupler being configured to lock into engagement when the bottom edge of the photovoltaic panel assembly is urged toward the top edge of a like photovoltaic panel assembly; and

electrical wiring beneath the photovoltaic panel assembly for coupling the electrical energy produced by the panel assembly with electrical energy produced by like panel assemblies in an array;

one of the front edge coupler and the back edge coupler comprising a ramp and the other one of the front edge coupler and the back edge coupler comprising a ramp follower, the ramp and ramp follower being configured and positioned to engage one another as the front edge of the photovoltaic panel assembly is urged toward the back edge of a like photovoltaic panel assembly and then to allow the front edge of the photovoltaic panel assembly to drop onto the back edge of the like photovoltaic panel assembly in overlying relationship.

13. A photovoltaic panel assembly as claimed in claim **12** wherein the back edge coupler comprises the ramp and the front edge coupler comprises the ramp follower.

14. A photovoltaic panel assembly as claimed in claim **13** wherein the ramp follower comprises a downwardly projecting tongue.

15. A photovoltaic panel assembly as claimed in claim **14** wherein the front edge and back edge couplers define a cable race for the routing of the electrical wiring between like panel assemblies of the array.

16. A photovoltaic panel assembly as claimed in claim **14** wherein one of the front edge and back edge couplers defines a ground channel configured to receive a ground wire for electrically grounding the photovoltaic panel assembly.

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